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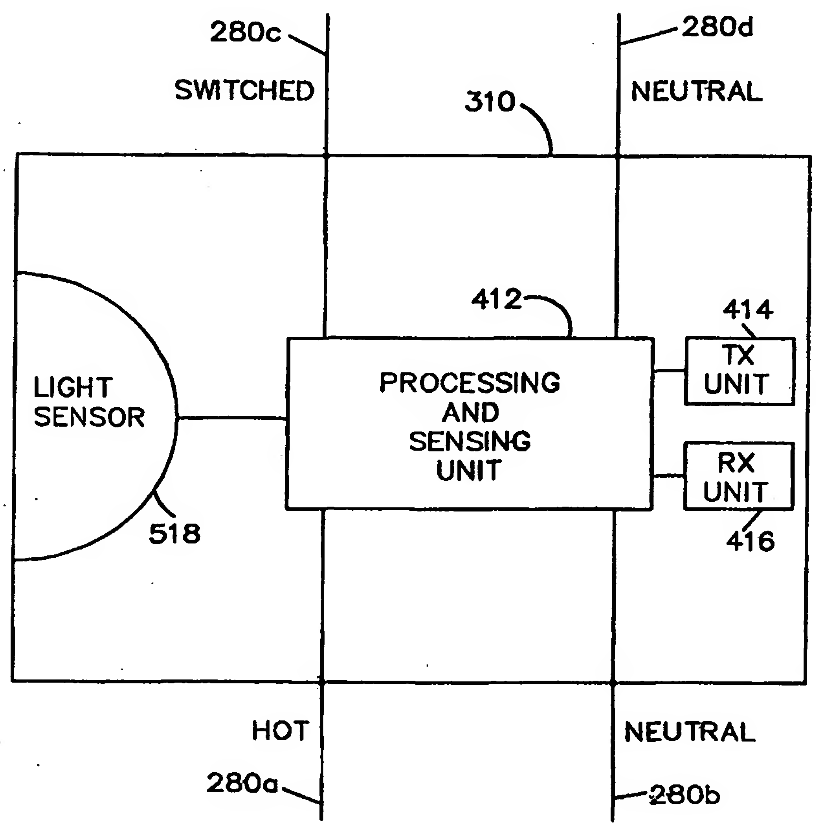
(54) Title: MONITORING AND CONTROL SYSTEMS AND METHODS

(57) Abstract

A system and method for remotely monitoring and/or controlling an apparatus, utilizes one or more monitoring and control units (412, 414, 416), each coupled to a respective device that is to be monitored and controlled. The monitoring and control devices (412, 414, 416) are each capable of transmitting monitoring data that includes at least an ID field and a status field to at least one base station. Each of the base stations includes an ID and status processing unit for processing the ID field of the monitoring data. A system embodying the invention provides centralized monitoring of multiple devices, such as street lamps or alarm systems, that are scattered over a geographical area. A method embodying the invention includes the steps of sensing at least one parameter of a monitored device, processing that at least one parameter to produce monitoring data and control information, and transmitting the monitoring data.



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MONITORING AND CONTROL SYSTEMS AND METHODS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to a system and method for remotely monitoring and/or controlling an apparatus such as a street lamp or an alarm system.

2. Background of the Related Art

In the 1880's, gas streetlights were first replaced with electrical lamps. The electrical power for these street lamps was provided from a central location. With the advent of electrical street lamps, the government finally had a centralized method for controlling the lamps by controlling the source of electrical power.

The early electrical street lamps were composed of arc lamps in which the illumination was produced by an arc of electricity flowing between two electrodes.

Currently, most street lamps still use arc lamps for illumination. The mercury-vapor lamp is the most common form of street lamp in use today. In this type of lamp, the illumination is produced by an arc which takes place in a mercury vapor.

Figure 1 shows the configuration of a typical mercury-vapor lamp. This figure is provided only for demonstration purposes since there are a variety of different types of mercury-vapor lamps.

The mercury-vapor lamp consists of an arc tube 110 which is filled with argon gas and a small amount of pure mercury. Arc tube 110 is mounted inside a large outer bulb 120 which encloses and protects the arc tube. Additionally, the outer bulb may be coated with phosphors to improve the color of the light emitted and reduce the ultraviolet radiation emitted. Mounting of arc tube 110 inside outer bulb 120 may be accomplished with an arc tube mount support 130 on the top and a stem 140 on the bottom.

Main electrodes 150a and 150b, with opposite polarities, are mechanically sealed at both ends of arc tube 110. The mercury-vapor lamp requires a sizeable voltage to start the arc between main electrodes 150a and 150b.

The starting of the mercury-vapor lamp is controlled by a starting circuit (not shown in Figure 1) which is attached between the power source (not shown in Figure 1) and the lamp. Unfortunately, there is no standard starting circuit for mercury-vapor lamps. After the lamp is started, the lamp current will continue to increase unless the starting circuit provides some means for limiting the current. Typically, the lamp current is limited by a resistor, which severely reduces the efficiency of the circuit, or by a magnetic device, such as a choke or a transformer, called a ballast.

During the starting operation, electrons move through a starting resistor 160 to a starting electrode 170 and across a short gap between starting electrode 170 and main electrode 150b of opposite polarity. The electrons cause ionization of some of the Argon

gas in the arc tube. The ionized gas diffuses until a main arc develops between the two opposite polarity main electrodes 150a and 150b. The heat from the main arc vaporizes the mercury droplets to produce ionized current carriers. As the lamp current increases, the ballast acts to limit the current and reduce the supply voltage to maintain stable operation and extinguish the arc between main electrode 150b and starting electrode 170.

Because of the variety of different types of starter circuits, it is virtually impossible to characterize the current and voltage characteristics of the mercury-vapor lamp. In fact, the mercury-vapor lamp may require minutes of warm-up before light is emitted. Additionally, if power is lost, the lamp must cool and the mercury pressure must decrease before the starting arc can start again.

The mercury-vapor lamp has become one of the predominant types of street lamp with millions of units produced annually. The current installed base of these street lamps is enormous with more than 500,000 street lamps in Los Angeles alone. The mercury-vapor lamp is not the most efficient gaseous discharge lamp, but is preferred for use in street lamps because of its long life, reliable performance, and relatively low cost.

Although the mercury-vapor lamp has been used as a common example of current street lamps, there is increasing use of other types of lamps such as metal halide and high pressure sodium. All of these types of lamps require a starting circuit which makes it virtually impossible to characterize the current and voltage characteristics of the lamp.

Figure 2 shows a lamp arrangement 201 with a typical lamp sensor unit 210 which is situated between a power source 220 and a lamp assembly 230. The lamp assembly 230 includes a lamp 240 (such as the mercury-vapor lamp presented in Figure 1) and a starting circuit 250.

Most cities currently use automatic lamp control units to control the street lamps. These lamp control units provide an automatic, but decentralized, control mechanism for turning the street lamps on at night and off during the day.

The lamp sensor unit 210 includes a light sensor 260 and a relay 270, as shown in Figure 2. The lamp sensor unit 210 is electrically coupled between the external power source 220 and the starting circuit 250 of the lamp assembly 230. There is a hot line 280a and a neutral line 280b providing electrical connection between power source 220 and the lamp sensor unit 210. Additionally, there is a switched line 280c and a neutral line 280d providing electrical connection between the lamp sensor unit 210 and the starting circuit 250 of the lamp assembly 230.

From a physical standpoint, most lamp sensor units 210 use a standard three prong plug, for example a twist lock plug, to connect to the back of the lamp assembly 230. The three prongs couple to hot line 280a, switched line 280c, and neutral lines 280b and 280d. In other words, the neutral lines 280b and 280d are both connected to the same physical prong since they are at the same electrical potential. Some systems also have a ground

wire, but no ground wire is shown in Figure 2 since it is not relevant to the operation of the lamp sensor unit 210.

The power source 220 may be a standard 115 Volt, 60 Hz source from a power line. Of course, a variety of alternatives are available for the power source 220 such as a 220 Volt, 50 Hz source from a power line. Additionally, the power source 220 may be a DC voltage source or, in certain remote regions, it may be a battery which is charged by a solar reflector.

The operation of the lamp sensor unit 210 is fairly simple. At sunset, when the light from the sun decreases below a sunset threshold, the light sensor 260 detects this condition and causes the relay 270 to close. Closure of the relay 270 results in electrical connection of hot line 280a and switched line 280c with power being applied to the starting circuit 250 of the lamp assembly 230 to ultimately produce light from the lamp 240. At sunrise, when the light from the sun increases above a sunrise threshold, the light sensor 260 detects this condition and causes the relay 270 to open. Opening of the relay 270 eliminates electrical connection between hot line 280a and switched line 280c and causes the removal of power from the starting circuit 250, which turns the lamp 240 off.

The lamp sensor unit 210 provides an automated, distributed control mechanism to turn the lamp assembly 230 on and off. Unfortunately, it provides no mechanism for centralized monitoring of the street lamp to determine if the lamp is functioning

properly. This problem is particularly important in regard to the street lamps on major boulevards and highways in large cities. When a street lamp burns out over a highway, it is often not replaced for a long period of time because the maintenance crew will only schedule a replacement lamp when someone calls the city maintenance department and identifies the exact pole location of the bad lamp. Since most automobile drivers will not stop on the highway just to report a bad street lamp, a bad lamp may go unreported indefinitely.

Additionally, if a lamp is producing light but has a hidden problem, visual monitoring of the lamp will never be able to detect the problem. Some examples of hidden problems relate to current, when the lamp is drawing significantly more current than is normal, or voltage, when the power supply is not supplying the appropriate voltage level to the street lamp.

Furthermore, the present system of lamp control, in which an individual light sensor is located at each street lamp, is a distributed control system which does not allow for centralized control. For example, if the city wanted to turn on all of the street lamps in a certain area at a certain time, this could not be done because of the distributed nature of the present lamp control circuits.

Because of these limitations, a new type of lamp monitoring and control system is needed which allows centralized monitoring and/or control of the street lamps in a geographical area.

One attempt to produce a centralized control mechanism is a product called the RadioSwitch made by Cetronic. The RadioSwitch is a remotely controlled time switch for installation on the DIN-bar of control units. It is used for remote control of electrical equipment via local or national paging networks. Unfortunately, the RadioSwitch is unable to address most of the problems listed above.

Since the RadioSwitch is receive only (no transmit capability), it only allows one to remotely control external equipment. It is impossible to monitor the status of street lamps using the RadioSwitch. Furthermore, since the communication link for the RadioSwitch is via paging networks, it is unable to operate in areas in which paging does not exist (for example, large rural areas in the United States). Additionally, although the RadioSwitch can be used to control street lamps, it does not use the standard three prong interface used by the present lamp control units. Accordingly, installation is difficult because it cannot be used as a plug-in replacement for the current lamp control units.

Because of these limitations of the available equipment, there exists a need for a new type of lamp monitoring and control system which allows centralized monitoring and/or control of the street lamps in a geographical area. More specifically, this new

system must be inexpensive, reliable, and able to handle the traffic generated by communication with the millions of currently installed street lamps.

Although the above discussion has presented street lamps as an example, there is a more general need for a new type of monitoring and control system which allows centralized monitoring and/or control of units distributed over a large geographical area.

With regard to the alarm monitoring and control aspects of the invention, a variety of prior art alarm systems have been developed for the protection of property. Such alarm systems are used to detect different types of alarm conditions such as a robbery, a fire, or other emergency conditions. However, the mere detection of an alarm condition is frequently not sufficient to allow a proper response.

A variety of attempts have been made to deal with the issue of alarm systems. For example, U.S. Patent No. 5,164,979 to Choi discloses a security system using telephone lines to transmit video images to a remote supervisory location. Unfortunately, the effectiveness of the Choi system is limited because it relies on telephone lines to relay the alarm information back to a supervisory site. A skilled burglar will generally cut the phone lines to a location before committing a robbery so that no security information, or other forms of communication, can be transmitted during the course of the robbery. Furthermore, Choi does not provide for any type of transmission network in which

individual neighborhoods can be grouped together as neighborhoods, rather he provides for a single supervisory site with direct communication to each of the security systems.

U.S. Patent No. 5,155,474 to Park et al. discloses a photographic security system which detects the presence of an intruder and switches on an illumination system and sound system, and activates a still camera to take a picture of the illuminated intruder. The sound system is used to mask the operation of the camera so that the intruder is unaware the picture has been taken. The problem with the Park system is that it provides no means for either transmitting the photographic image or transmitting an intruder detection signal to a main site. In other words, although the Park system may allow the detection and photography of an intruder, it does not provide any mechanism for communicating this information back to another location.

U.S. Patent No. 4,522,146 to Carlson discloses a burglar alarm system which incorporates photographic equipment to photograph an intruder and also includes a pneumatically operated audible alarm. Carlson suffers from the same problems noted above for the Park system, i.e. it provides no method for sending either image data or a signal indicating that an alarm has occurred back to a supervisory site.

U.S. Patent No. 4,347,590 to Heger et al. discloses an area surveillance system which includes an ultrasonic intrusion detector, an electronic range finder, and an instant camera. Heger et al. disclose a system in which the intruder is detected and the range

finder is used to focus the camera on the intruding subject. After focusing, a series of pictures of the area are taken and these pictures are used to provide identification of the intruder. The Heger system has the same problems as the Carlson and Park systems in that it does not provide any mechanism for transmitting either the photographic data or an alarm detection signal back to a central site.

The above references are incorporated by reference herein where appropriate for teachings of additional or alternative details, features and/or technical background.

SUMMARY OF THE INVENTION

The present invention provides a monitoring and control system and method for use with street lamps, alarm systems and other devices that solves the problems described above. While certain embodiments of the invention are described specifically with respect to use with street lamps and alarm systems, the invention is more generally applicable to any application requiring centralized monitoring and/or control of units distributed over a large geographical area.

A system embodying the invention includes at least one base station, and a plurality of transmitting units. Each transmitting unit will monitor the status or condition of at least one monitored device, such as a street light or an alarm system, and transmit the status information to a base station. Each transmitting unit will have a

different identification number which is also communicated to the base station. Each transmitting unit may be capable of transmitting data packets over multiple channels. Each transmitting unit may also be configured to communicate on different channels. The transmitting units may communicate with a base station via RF, wire, coaxial cable, fiber optics or other communications means.

An object of the present invention is to provide a system for monitoring and controlling lamps, alarm units, or any device over a large geographical area using radio or other types of communications. Another object of the invention is to provide a method for randomizing transmit times and channel numbers to reduce the probability of a data packet collision.

Another object of the current invention is to provide an ID and status processing unit in a base station that receives signals from many transmitters distributed over a geographical area. Another object of the invention is to monitor, record and process signals from multiple locations to create statistical profiles.

An advantage of the present invention is that it solves the problem of efficiently providing centralized monitoring and/or control of multiple street lamps, alarm systems or other devices distributed over a geographical area.

Another advantage of the present invention is that, when used on street lamps, a monitoring and transmitting unit uses the standard three prong plug of current street

lamps, so the device is easy to install in place of the millions of currently installed lamp control units. Such a monitoring and control unit may include a current and/or voltage sensor to monitor the electrical power consumed by a street lamp. Also, the transmitting unit may deliberately delay transmitting a change in the status of a street lamp to allow current to stabilize and to allow a relay to settle. If such delays are provided before status information is communicated, false triggering information can be reduced.

Another advantage of the present invention is that it allows multiple base stations to be connected to a main station in a network topology to increase the amount of monitoring data in the overall system.

A transmitting unit of a system embodying the invention may include a transmitter and a modified directional discontinuity ring radiator, and the modified directional discontinuity ring radiator may include a plurality of loops for resonance at a desired frequency range.

A method embodying the invention may include a step of transmitting monitoring data based on a pseudo-random reporting start time delay and pseudo-random reporting delta time. The method may also include a step of selecting a transmit channel or frequency in a pseudo-random manner. The pseudo-random nature of these values may be based on the serial number of the lamp monitoring and control unit.

One embodiment of the invention allows the combination of alarm and lamp monitoring and control functions in a single monitoring and control unit. This embodiment may allow for collection and transmission of an image when an alarm condition is detected.

Additional objects, advantages, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objects and advantages of the invention may be realized and attained as particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in detail with reference to the following drawings in which like reference numerals refer to like elements, and wherein:

Figure 1 shows the configuration of a typical mercury-vapor lamp;

Figure 2 shows a typical street lamp arrangement, including a lamp sensor unit situated between a power source and a lamp assembly;

Figure 3 shows another street lamp arrangement, including a lamp monitoring and control unit situated between a power source and a lamp assembly;

Figure 4 shows a lamp monitoring and control unit, according to an embodiment of the invention, including a processing and sensing unit, a transmit unit, and a receive unit;

Figure 5 shows a lamp monitoring and control unit, according to another embodiment of the invention, including a processing and sensing unit, a transmit unit, a receive unit, and a light sensor;

Figure 6 shows a lamp monitoring and control unit, according to another embodiment of the invention, including a processing and sensing unit, a transmit unit, and a light sensor;

Figure 7 shows a lamp monitoring and control unit, according to another embodiment of the invention, including a microprocessing unit, an A/D unit, a current sensing unit, a voltage sensing unit, a relay, a transmit unit, and a light sensor;

Figure 8 shows a general monitoring and control unit, according to another embodiment of the invention, including a processing and sensing unit, a transmit unit, and a receive unit;

Figure 9 shows a monitoring and control system, according to another embodiment of the invention, including a base station and a plurality of monitoring and control units;

Figure 10 shows a monitoring and control system, according to another embodiment of the invention, including a plurality of base stations, each having a plurality of associated monitoring and control units;

Figure 11 shows an example frequency channel plan for a monitoring and control system, according to an embodiment of the invention;

Figure 12 shows a typical directional discontinuity ring radiator (DDRR) antenna;

Figure 13 shows a modified DDRR antenna, according to another embodiment of the invention;

Figures 14A-B show data packet formats, according to another embodiment of the invention, for packet data transmitted between a monitoring and control unit and a base station;

Figure 15 shows an example of bit location values for a status byte in a data packet format, according to another embodiment of the invention;

Figures 16A-C show a base station for use in a monitoring and control system, according to another embodiment of the invention;

Figure 17 shows a monitoring and control system, according to another embodiment of the invention, having a main station coupled through a plurality of communication links to a plurality of base stations;

Figure 18 shows a base station, according to another embodiment of the invention;

Figures 19A-E show steps of a method embodying the invention for monitoring and controlling a street lamp and transmitting the street lamp status;

Figure 20 shows an alarm monitoring and control unit, according to one embodiment of the invention, having a processing unit, a transmit unit, and receiving units;

Figure 21 shows an alarm monitoring and control unit, according to an another embodiment of the invention, having a processing unit, a transmit unit, receiving units, and an imaging unit;

Figure 22 shows an alarm monitoring and control unit, according to another embodiment of the invention, having a processing unit, a transmit unit, receiving units, an imaging unit, an interface, and a memory;

Figure 23 shows an alarm unit, according to a preferred embodiment of the invention, having an alarm detection unit and a transmit unit;

Figure 24 shows an alarm unit, according to another embodiment of the invention, having an alarm detection unit, a transmit unit, a processing unit, and an imaging unit;

Figure 25 shows an interrogation unit having a processing unit, an interface, and a storage unit, according to one embodiment of the invention;

Figure 26 shows a monitoring and control system according to another embodiment of the invention having a main station coupled through communication links to a plurality of base stations; and

Figure 27 shows steps of a method, according to another embodiment of the invention, for monitoring and controlling an alarm.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Preferred embodiments of a lamp monitoring and control unit (LMCU), a lamp monitoring and control system (LMCS), and a method which allows centralized monitoring and/or control of street lamps will first be described with reference to Figures 1-19E. Subsequently, an alarm monitoring and control system and method according to another embodiment of the invention will be described with reference to Figures 20-27. While embodiments of the invention are described with reference to street lamps and alarm systems, the invention is not limited to these applications and can be used in any application which requires a monitoring and control system for centralized monitoring and/or control of devices distributed over a geographical area. Additionally, the term

"street lamp" in this disclosure is used in a general sense to describe any type of street lamp, area lamp, or outdoor lamp.

Figure 3 shows a lamp arrangement 301 which includes a lamp monitoring and control unit 310 embodying the invention. The lamp monitoring and control unit 310 is situated between a power source 220 and a lamp assembly 230'. The lamp assembly 230' includes a lamp 240 and a starting circuit 250'.

The lamp monitoring and control unit 310 provides several functions, including a monitoring function which is not provided by known lamp control units 210, such as the one shown in Figure 2. The lamp monitoring and control unit 310 is electrically located between an external power supply 220 and a starting circuit 250' of the lamp assembly 230'. From an electrical standpoint, there is a hot line 280a and a neutral line 280b between the power supply 220 and the lamp monitoring and control unit 310. Additionally, there is a switched line 280c and a neutral line 280d between the lamp monitoring and control unit 310 and the starting circuit 250' of the lamp assembly 230'.

From a physical standpoint, the lamp monitoring and control unit 310 may use a standard three-prong twist lock plug to connect to the back of a standard street lamp assembly 230'. These three-prong plugs are currently used to connect a street lamp with a sensor that controls the lamp based on ambient light conditions. The three prongs in the standard three-prong plug represent a hot line 280a, a switched line 280c, and neutral

lines 280b and 280d. In other words, the neutral lines 280b and 280d are both connected to the same physical prong and share the same electrical potential.

Although use of a three-prong plug is desirable because of the substantial number of street lamps using this type of standard plug, it is well known to those skilled in the art that a variety of additional types of electrical connections may be used in a device embodying present invention. For example, a standard power terminal block or AMP power connector may be used.

Figure 4 shows a lamp monitoring and control unit 310, the operation of which will be discussed in more detail below along with particular embodiments of the unit. The lamp monitoring and control unit 310 includes a processing and sensing unit 412, a transmit (TX) unit 414, and an optional receive (RX) unit 416. The processing and sensing unit 412 is electrically connected to a hot line 280a, a switched line 280c, and neutral lines 280b and 280d. Furthermore, the processing and sensing unit 412 is connected to the TX unit 414 and the RX unit 416. In a standard application, the TX unit 414 may be used to transmit monitoring data and the RX unit 416 may be used to receive control information. For applications in which external control information is not required, the RX unit 416 may be omitted from the lamp monitoring and control unit 310.

Figure 5 shows a lamp monitoring and control unit 310, according to another embodiment of the invention, with a configuration similar to that shown in Figure 4. Here, however, the lamp monitoring and control unit 310 further includes a light sensor 518, analogous to the light sensor 216 of the device shown in Figure 2, which allows for some degree of local control. The light sensor 518 is coupled to the processing and sensing unit 412 to provide information regarding the level of ambient light. Accordingly, the processing and sensing unit 412 may receive control information either locally from the light sensor 518 or remotely from the RX unit 416.

Figure 6 shows another configuration for the lamp monitoring control unit 310, according to another embodiment of the invention, but without the RX unit 416. This embodiment of the lamp monitoring and control unit 310 can be used in applications in which only local control information, for example from a light sensor 518, is to be passed to the processing and sensing unit 412.

Figure 7 shows a more detailed implementation of the lamp monitoring and control unit 310 of Figure 6, according to one embodiment of the invention. This embodiment of the lamp monitoring and control unit 310 includes a three-prong plug 720 to provide hot 280a, neutral 280b and 280d, and switched 280c electrical connections. The hot 280a and neutral 280b and 280d electrical connections are connected to an optional switching power supply 710 in applications in which AC power is input and DC power

is required to power the circuit components of the lamp monitoring and control unit 310.

The light sensor 518 includes a photosensor 518a and associated light sensor circuitry 518b. The TX unit 414 includes a radio modem transmitter 414a and a built-in antenna 414b. The processing and sensing unit 412 includes microprocessor circuitry 412a, a relay 412b, current and voltage sensing circuitry 412c, and an analog-to-digital converter 412d.

The microprocessor circuitry 412a may include any standard microprocessor/ microcontroller such as the Intel 8751 or Motorola 68HC16. Additionally, in applications in which cost is an issue, the microprocessor circuitry 412a may comprise a small, low cost processor with built-in memory such as the Microchip PIC 8 bit microcontroller. Furthermore, the microprocessor circuitry 412a may be implemented by using a PAL, EPLD, FPGA, or ASIC device.

The microprocessor circuitry 412a receives and processes input signals and outputs control signals. For example, the microprocessor circuitry 412a receives a light sensing signal from the light sensor 518. This light sensing signal may either be a threshold indication signal, that is, providing a digital signal, or some form of analog signal. Based upon the value of the light sensing signal, the microprocessor circuitry 412a may alternatively or additionally execute software to output a relay control signal to a relay 412a which switches switched power line 280c to hot power line 280a.

The microprocessor circuitry 412a may also interface to other sensing circuitry. For example, the lamp monitoring and control unit 310 may include current and voltage sensing circuitry 412c which senses the voltage of the switched power line 280c and also senses the current flowing through the switched power line 280c. The voltage sensing operation may produce a voltage ON signal which is sent from the current and voltage sensing circuitry 412c to the microprocessor circuitry 412a. This voltage ON signal can be of a threshold indication, that is, some form of digital signal, or it can be an analog signal.

The current and voltage sensing circuitry 412c can also output a current level signal indicative of the amount of current flowing through the switched power line 280c. The current level signal can interface directly to the microprocessor circuitry 412a or, alternatively, it can be coupled to the microprocessing circuitry 412a through an analog-to-digital converter 412b. The microprocessor circuitry 412a can produce a CLOCK signal which is sent to the analog-to-digital converter 412d and which is used to allow A/D data to pass from the analog-to-digital converter 412d to the microprocessor circuitry 412a.

The microprocessor circuitry 412a can also be coupled to a radio modem transmitter 414a to allow monitoring data to be sent from the lamp monitoring control unit 310.

The configuration shown in Figure 7 is intended as an illustration of one way in which the present invention can be implemented. Other embodiments are certainly possible. For example, the analog-to-digital converter 412b may be combined into the microprocessor circuitry 412a for some applications. Furthermore, the memory for the microprocessor circuitry 412a may either be internal to the microprocessor circuitry or configured as an external EPROM, EEPROM, Flash RAM, dynamic RAM, or static RAM. The current and voltage sensor circuitry 412c may either be combined in one unit with shared components, or separated into two separate units. Furthermore, the current sensing portion of the current and voltage sensing circuitry 412c may include a current sensing transformer 413 and associated circuitry, as shown in Figure 7, or may be configured using different circuitry which also senses current.

In a preferred embodiment, the frequencies to be used by the TX unit 414 to communicate status information to a base station are selected by the microprocessor circuitry 412a. There are a variety of ways that these frequencies can be organized and used, examples of which will be discussed below.

Figure 8 shows a general monitoring and control unit 510 including a processing and sensing unit 520, a TX unit 530, and an optional RX unit 540. The monitoring and control unit 520 is coupled to a remote device 550. The monitoring and control unit 510 differs from the lamp monitoring and control unit 310 in that the monitoring and control

unit 510 is general-purpose and not limited to use with street lamps. The monitoring and control unit 510 can be used to monitor and control any remote device 550.

Figure 9 shows a monitoring and control system 600, according to one embodiment of the invention. The system 600 includes a base station 610 and a plurality of monitoring and control units (MCU) 510a-d, like the one shown in Figure 8. Each of the monitoring and control units 510a-d can transmit monitoring data through its associated TX unit 530 to the base station 610 and receive control information through a RX unit 540 from the base station 610.

Communication between the monitoring and control units 510a-d and the base station 610 can be accomplished in a variety of ways, depending on the application. The communications could be effected by radio frequency transmissions, wire, coaxial cable, fiber optics or other means. Radio Frequency is the currently preferred communication link due to the costs required to build the infrastructure for any of the other options.

Figure 10 shows a monitoring and control system 700, according to another embodiment of the invention, including a plurality of base stations 610a-c, each having a plurality of associated monitoring and control units 510a-h. Each base station 610a-c is generally associated with a particular geographic area of coverage. For example, the first base station 610a, communicates with monitoring and control units 510a-c in a limited

geographic area. If the monitoring and control units 510a-c are used for lamp monitoring and control, the geographic area may consist of a section of a city.

Although the example of geographic area is used to group the monitoring and control units 510a-c, it is well known to those skilled in the art that other groupings may be used. For example, to monitor and control remote devices 550 made by different manufacturers, the monitoring and control system 700 may use groupings in which one base station 610a services one manufacturer and another base station 610b services a different manufacturer. In this example, the base stations 610a and 610b may be servicing overlapping geographical areas.

Figure 10 also shows a communication link 716 between the base stations 610a-c. This communication link 716 is shown as a bus topology, but can alternately be configured in a ring, star, mesh, or other topology. An optional main station 710 can also be connected to the communication link 716 to receive and collect data from the base stations 610a-c. The media used for the communication link 716 between base stations 610a-c could be effected by radio frequency transmissions, wire, coaxial cable, fiber optics or other means.

Figure 11 shows an example of a frequency channel plan for communications between multiple monitoring and control units 510 and a base station 610 in the monitoring and control systems 600 or 700, according to one embodiment of the

invention. In this example table, interactive video and data service (IVDS) radio frequencies in the range of 218-219 MHZ are shown. The IVDS channels in Figure 11 are divided into two groups, Group A and Group B, with each group having nineteen channels spaced at 25 KHz steps. The first channel of the group A frequencies is located at 218.025 MHZ and the first channel of the group B frequencies is located at 218.525 MHZ.

Figure 12 shows a typical directional discontinuity ring radiator (DDRR) antenna 900. The DDRR antenna 900 is well known to those skilled in the art, and a detailed description of the operation and use of this antenna can be found in the American Radio Relay League (ARRL) Handbook, the appropriate sections of which are incorporated herein by reference. The problem with using the DDRR antenna 900 in applications such as a lamp monitoring and control unit 310 is that for the antenna to be effective in certain frequency ranges, such as the IVDS frequency range, the dimensions of the antenna become too large for convenience.

Figure 13 shows a modified DDRR antenna 1000, which could be used in an embodiment of the invention using the IVDS frequency range for data communications. The modified DDRR antenna 1000 is mounted on a PC board 1010 and includes a metal shield 1020, a coil segment 1060, a looped wire coil 1040, a first variable capacitor C1, and

a second variable capacitor C2. Additionally, a plastic assembly (not shown) may be included in the modified DDRR antenna 1000 to hold the looped wire coil 1040 in place.

The RF energy to be radiated is fed into an RF feed point 1050 and travels through a wire segment 1060 passing through a hole 1030 in a metal shield 1020 to the variable capacitor C2. The variable capacitor C2 is used to match the input impedance of the modified DDRR antenna 1000 to an optimum value. In one embodiment of the invention, the variable capacitor C2 is set to provide an impedance of 50 ohms. The looped wire coil 1040 is looped several times, as opposed to a typical DDRR antenna 900 which only has one loop. The looped wire coil 1040 may be coupled to a wire segment 1060, or both looped wire coil 1040 and wire segment 1060 may be part of a continuous piece of wire, as shown. The end of the wire coil 1040 is coupled to the capacitor C1, which tunes the modified DDRR antenna 1000 for resonance at the desired frequency.

The modified DDRR antenna 1000 has multiple loops in the wire coil 1040 which allow the antenna to resonate at particular frequencies. For example, if the typical DDRR antenna 900 having a diameter of approximately 5 inches is modified to include three to six loops, then the diameter can be decreased to less than 4", and still efficiently resonate in the IVDS frequency range. In other words, if a typical DDRR antenna 900 has a 4" diameter, it will have poor resonance in the IVDS frequency range. In contrast, a modified DDRR antenna 1000 having a 4" diameter, will have excellent resonance in the

IVDS frequency range. Accordingly, a modified DDRR antenna 1000 provides for an efficient transformation of input RF energy to radiant energy in an E-M field due to its improved resonance at the desired frequencies, and the impedance match to the input RF source. The exact number of additional loops and spacing for the modified DDRR antenna 1000 depends on the frequency range selected.

Furthermore, if the lamp monitoring and control unit 310 includes RX unit 416, as shown in Figure 4, modified DDRR antenna 1000 can be shared by the TX unit 414 and the RX unit 416. Alternatively, the RX unit 416 and the TX unit 414 may use separate antennas.

Figures 14A-B show data packet formats, according to two embodiments of the invention, for packet data transferred between a monitoring and control unit 510 and a base station 610. Figure 14A shows a general data packet format, according to one embodiment of the invention, including a start field 910, an ID field 912, a status field 914, a data field 916, and a stop field 918.

The start field 910 is located at the beginning of the packet and indicates the start of the packet.

The ID field 912 is located after the start field 910 and indicates the ID for the source of the packet transmission, and optionally the ID for the destination of the transmission. Inclusion of a destination ID depends on the system topology and

geographic layout. For example, if an RF transmission is used for the communications link, and if a base station 610a is located far enough from the other base stations so that associated monitoring and control units 510a-c are out of range from the other base stations, then no destination ID is required. Furthermore, if the communication link between the base station 610a and associated monitoring and control units 510a-c uses wire cable or fiber optics, rather than RF, then there would be no requirement for a destination ID.

The status field 914 is located after the ID field 912 and indicates the status of the monitoring and control unit 510. For example, if the monitoring and control unit 510 is used in conjunction with street lamps, the status field 914 could indicate that the street lamp was turned on or off at a particular time.

The data field 916 is located after the status field 914 and includes any data that may be associated with the indicated status. For example, if a monitoring and control unit 510 is used in conjunction with street lamps, the data field 916 may be used to provide an A/D value for the lamp voltage and/or current after the street lamp has been turned on.

The stop field 918 is located after the data field 916 and indicates the end of the packet.

Figure 14B shows a more detailed packet format, according to another embodiment of the invention, including a start byte 930, ID bytes 932, a status byte 934, a data byte 936, and a stop byte 938. Each byte comprises eight bits of information.

The start byte 930 is located at the beginning of the packet and indicates the start of the packet. The start byte 930 will use a unique value that will indicate to the destination that a new packet is beginning. For example, the start byte 930 can be set to a value such as 02 hex.

The ID bytes 932 can be four bytes located after the start byte 930 to indicate the ID for the source of the packet transmission, and optionally the ID for the destination of the transmission. The ID bytes 932 can use all four bytes as a source address, which allows for 2^{32} (over 4 billion) unique monitoring and control units 510. Alternately, the ID bytes 932 can be divided up so that some of the bytes are used for a source ID and the remainder are used for a destination ID. For example, if two bytes are used for the source ID and two bytes are used for the destination ID, the system can include 2^{16} (over 64,000) unique sources and destinations.

The status byte 934 is located after the ID bytes 932 and indicates the status of monitoring and control unit 510. The status may be encoded in the status byte 934 in a variety of ways. For example, if each potential value of the status byte indicates a unique status, then there exists 2^{8} (256) unique status values. However, if each bit of the status

byte 934 is reserved for a particular status indication, then there exists only 8 unique status values (one for each bit in the byte). Furthermore, certain combinations of bits may be reserved to indicate an error condition. For example, a status byte 934 setting of FF hex (all ones) can be reserved for an error condition.

The data byte 936 is located after the status byte 934 and includes any data that may be associated with the indicated status. For example, if a monitoring and control unit 510 is used in conjunction with street lamps, the data byte 936 may be used to provide an A/D value for the lamp voltage or current after the street lamp has been turned on.

The stop byte 938 is located after the data byte 936 and indicates the end of the packet. The stop byte 938 will use a unique value that will indicate to the destination that the current packet is ending. For example, the stop byte 938 can be set to a value such as 03 hex.

Figure 15 shows an example of bit location values for a status byte 934 in a data packet format according to an embodiment of the invention. For example, if a monitoring and control unit 510 is used in conjunction with street lamps, each bit of the status byte can be used to convey monitoring data.

The bit values are listed in the table with the most significant bit (MSB) at the top of the table and the least significant bit (LSB) at the bottom. The MSB, bit 7, can be used to indicate if an error condition has occurred. Bits 6-2 are unused. Bit 1 indicates whether

daylight is present and will be set to 0 when the street lamp is turned on and set to 1 when the street lamp is turned off. Bit 0 indicates whether AC voltage has been switched to the street lamp. Bit 0 is set to 0 if the AC voltage is off and set to 1 if the AC voltage is on.

Figures 16A-C show a base station 1100 for use in a monitoring and control system using RF, according to another embodiment of the invention.

Figure 16A shows a base station 1100 which includes an RX antenna system 1110, a receiving system front end 1120, a multi-port splitter 1130, a bank of RX modems 1140a-c, and a computing system 1150.

The RX antenna system 1110 receives RF monitoring data and can be implemented using a single antenna or an array of interconnected antennas depending on the topology of the system. For example, if a directional antenna is used, the RX antenna system 1110 may include an array of four of these directional antennas to provide 360 degrees of coverage.

The receiving system front end 1120 is coupled to the RX antenna system 1110 for receiving the RF monitoring data. The receiving system front end 1120 can be implemented in a variety of ways. For example, a low noise amplifier (LNA) and pre-selecting filters can be used in applications which require high receiver sensitivity. The receiving system front end 1120 outputs received RF monitoring data.

The multi-port splitter 1130 is coupled to the receiving system front end 1120 for receiving the received RF monitoring data. The multi-port splitter 1130 takes the received RF monitoring data from the receiving system front end 1120 and splits it to produce split RF monitoring data.

The RX modems 1140a-c are coupled to the multi-port splitter 1130 and receive the split RF monitoring data. The RX modems 1140a-c each demodulate their respective split RF monitoring data line to produce a respective received data signal. The RX modems 1140a-c can be operated in a variety of ways depending on the configuration of the system. For example, if twenty channels are being used, twenty RX modems 1140 can be used, with each RX modem set to a different fixed frequency. On the other hand, in a more sophisticated configuration, frequency channels can be dynamically allocated to RX modems 1140a-c depending on the traffic requirements.

The computing system 1150 is coupled to the RX modems 1140a-c for receiving the received data signals. The computing system 1150 can include one or many individual computers. Additionally, the interface between the computing system 1150 and the RX modems 1140a-c can be any type of data interface, such as an RS-232 or an RS-422 interface.

The computing system 1150 may include an ID and status processing unit (ISPU) 1152 which processes ID and status data from the packets of monitoring data in the

demodulated signals. The ISPU 1152 can be implemented as software, hardware, or firmware. Using the ISPU 1152, the computing system 1150 can decode the packets of monitoring data in the demodulated signals, or can simply pass, without decoding, the packets of monitoring data on to another device, or can both decode and pass the packets of monitoring data.

For example, if the ISPU 1152 is implemented as software running on a computer, it can process and decode each packet. Furthermore, the ISPU 1152 can include a user interface, such as a graphical user interface, to allow an operator to view the monitoring data. Furthermore, the ISPU 1152 can include an interface to a database in which the monitoring data is stored.

The inclusion of a database is particularly useful for producing statistical norms on the monitoring data, either relating to one monitoring and control unit over a period of time or relating to performance of all of the monitoring and control units. For example, if the present invention is used for lamp monitoring and control, the current draw of a lamp can be monitored over a period of time and a profile created. Furthermore, an alarm threshold can be set if a new piece of monitored data deviates from the norm established in the profile. This feature is helpful for monitoring and controlling lamps because the precise current characteristics of each lamp can vary greatly. By allowing the database to create a unique profile for each lamp, the problem related to different lamp

currents can be overcome so that an automated system for quickly identifying lamp problems is established.

Figure 16B shows an alternate configuration for a base station 1100, according to a further embodiment of the invention, which includes all of the elements discussed in regard to Figure 16A and further includes a TX modem 1160, a transmitting system 1162, and a TX antenna 1164. The base station 1100, as shown in Figure 16B, can be used in applications which require a TX channel for control of remote devices 550.

The TX modem 1160 is coupled to a computing system 1150 for receiving control information. The control information is modulated by the TX modem 1160 to produce modulated control information.

The transmitting system 1162 is coupled to the TX modem 1160 for receiving the modulated control information. The transmitting system 1162 can have a variety of different configurations depending on the application. For example, if higher transmit power output is required, the transmitting system 1162 can include a power amplifier. If necessary, the transmitting system 1162 can include isolators, bandpass, lowpass, or highpass filters to prevent out-of-band signals. After receiving the modulated control information, the transmitting system 1162 outputs a TX RF signal.

The TX antenna 1164 is coupled to the transmitting system 1162 for receiving the TX RF signal and transmitting a transmitted TX RF signal. It is well known to those

skilled in the art that a TX antenna 1164 may be coupled with a RX antenna system 1110 using a duplexer for example.

Figure 16C shows a base station 1100 as part of a monitoring and control system, according to another embodiment of the invention. The base station 1100 has already been described with reference to Figure 16A. Additionally, the computing system 1150 of the base station 1100 can be coupled to a communication link 1170 for communicating with a main station 1180 or a further base station 1100a.

The communication link 1170 may be implemented using a variety of technologies such as: a standard phone line, DDS line, ISDN line, T1, fiber optic line, or RF link. The topology of the communication link 1170 can vary depending on the application and can be: star, bus, ring, or mesh.

Figure 17 shows a monitoring and control system 1200, according to another embodiment of the invention, having a main station 1230 coupled through a plurality of communication links 1220a-c to a plurality of respective base stations 1210a-c. The base stations 1210a-c can have a variety of configurations, such as those shown in Figures 11A-B. The communication links 1220a-c allow respective base stations 1210a-c to pass monitoring data to the main station 1230 and to receive control information from the main station 1230. Processing of the monitoring data can either be performed at the base stations 1210a-c or at the main station 1230.

Figure 18 shows a base station 1300 which is coupled to a communication server 1340 via a communication link 1330, according to another embodiment of the invention. The base station 1300 includes an antenna and preselector system 1305, a receiver modem group (RMG) 1310, and a computing system 1320.

The antenna and preselector system 1305 are similar to the RX antenna system 1110 and receiving system front end 1120 which were previously discussed. The antenna and preselector system 1305 can include either one antenna or an array of antennas and preselection filtering as required by the application. The antenna and preselector system 1305 receives RF monitoring data and outputs preselected RF monitoring data.

The Receiver modem group (RMG) 1310 includes a low noise pre-amplifier 1312, a multi-port splitter 1314, and several RX modems 1316a-c. The low noise pre-amplifier 1312 receives the preselected RF monitoring data from the antenna and preselector system 1305 and outputs amplified RF monitoring data.

The multi-port splitter 1314 is coupled to low the noise pre-amplifier 1312 for receiving the amplified RF monitoring data and outputting split RF monitoring data on multiple lines.

The RX modems 1316a-c are coupled to the multi-port splitter 1314 for receiving and demodulating one of the split RF monitoring data lines and outputting a received data signal (RXD) 1324, a received clock signal (RXC) 1326, and a carrier detect signal (CD)

1328. These signals can use a standard interface such as RS-232 or RS-422, or can use a proprietary interface.

The computing system 1320 includes at least one base site computer 1322 for receiving RXD, RXC, and CD from RX modems 1316a-c, and outputting a serial data stream.

The computing system 1320 further includes an ID and status processing unit (ISPU) 1323 which processes ID and status data from the packets of monitoring data in the RXD signal. The ISPU 1323 can be implemented as software, hardware, or firmware. Using the ISPU 1323, the computing system 1320 can decode the packets of monitoring data in the demodulated signals, or can simply pass, without decoding, the packets of monitoring data on to another device in the serial data stream, or can both decode and pass the packets of monitoring data.

The communication link 1330 includes a first communication interface 1332, a second communication interface 1334, a first interface line 1336, a second interface line 1342, and a link 1338.

The first communication interface 1332 receives the serial data stream from the computing system 1320 of the base station 1300 via the first interface line 1336. The first communication interface 1332 can be co-located with the computing system 1320 or be

remotely located. The first communication interface 1332 can be implemented in a variety of ways using, for example, a CSU, DSU, or modem.

The second communication interface 1334 is coupled to the first communication interface 1332 via a link 1338. The link 1338 can be implemented using a standard phone line, a DDS line, an ISDN line, T1, a fiber optic line, or a RF link. The second communication interface 1334 can be implemented similarly to the first communication interface 1332 using, for example, a CSU, DSU, or modem.

The communication link 1330 outputs communicated serial data from the second communication interface 1334 via a second communication line 1342.

The communication server 1340 is coupled to the communication link 1330 for receiving communicated serial data via the second communication line 1342. The communication server 1340 receives several lines of communicated serial data from several computing systems 1320 and multiplexes them to output multiplexed serial data on to a data network. The data network can be a public or private data network such as an internet or intranet.

Figures 19A-E show steps of a method for implementation of logic for a lamp monitoring and control unit 310, and for a lamp monitoring and control system 600, according to a further embodiment of the invention. These methods may be

implemented in a variety of ways, including software in microprocessor circuitry 412a or customized logic chips.

Figure 19A shows one method for energizing and de-energizing a street lamp and transmitting associated monitoring data. The method of Figure 19A shows a single transmission for each control event. The method begins with a start block 1400 and proceeds to step 1410, which involves checking AC and Daylight Status. The method proceeds to step 1420, which is a decision block to determine whether there has been a change in the AC or Daylight Status.

If a change occurred, the method proceeds to a Debounce Delay step 1422, which involves inserting a Debounce Delay. For example, the Debounce Delay may be 0.5 seconds. After the Debounce Delay step 1422, the method leads back to the Check AC and Daylight Status step 1410.

If no change occurred, step 1420 proceeds to step 1430, which is a decision block to determine whether the lamp should be energized. If the lamp should be energized, then the method proceeds to step 1432, which turns the lamp on. After step 1432, when the lamp is turned on, the method proceeds to step 1434 which involves a Current Stabilization Delay to allow the current in the street lamp to stabilize. The amount of delay for current stabilization depends upon the type of lamp used. However, for a

typical vapor lamp, a ten minute stabilization delay is appropriate. After step 1434, the method leads back to step 1410, which checks the AC and Daylight Status.

Returning to step 1430, if the lamp is not to be energized, then the method proceeds to step 1440, which is a decision block to determine whether a lamp should be de-energized. If the lamp is to be de-energized, the method proceeds to step 1442, which involves turning the Lamp Off. After the lamp is turned off, the method proceeds to step 1444, in which the relay is allowed a Settle Delay time. The Settle Delay time is dependent upon the particular relay used and may be, for example, set to 0.5 seconds. After step 1444, the method returns to step 1410 to check the AC and Daylight Status.

Returning to step 1440, if the lamp is not to be de-energized, the method proceeds to step 1450, in which an error bit is set, if required. The method then proceeds to step 1460, in which data is read. For example, the data may be read from an analog-to-digital converter 412d for reading a current or voltage level, as shown in Figure 7.

The method then proceeds from step 1460 to step 1470, which checks to see if a transmit is required. If no transmit is required, the method proceeds to step 1472, in which a Scan Delay is executed. The Scan Delay depends upon the circuitry used and, for example, may be 0.5 seconds. After step 1472, the method returns to step 1410, which checks AC and Daylight Status.

Returning to step 1470, if a transmit is required, then the method proceeds to step 1480 which performs a transmit operation. After the transmit operation of step 1480 is completed, the method then returns to step 1410, which checks AC and Daylight Status.

The steps of a method similar to the one described above are shown in Figure 19B. Because most of the steps are identical to those described above in connection with Figure 9A, only the differences will be discussed.

In this method, if a change in status is detected at step 1420, rather than simply executing step 1422, the Debounce Delay, the method performs several additional steps. First, in step 1424, a check is performed to determine whether daylight has occurred. If daylight has not occurred, then the method proceeds to step 1426, which executes a short Initial Delay. This short initial delay may be, for example, 0.5 seconds. After step 1426, the method proceeds to step 1422 and follows the same method as shown in Figure 19A.

Returning to step 1424, if daylight has occurred, the method proceeds to step 1428, which executes a long Initial Delay. The long Initial Delay associated with step 1428 should be a significantly larger value than the short Initial Delay associated with step 1426. For example, a long Initial Delay of 45 seconds may be used. The long Initial Delay of step 1428 is used to prevent a false triggering which de-energizes the lamp. Such a false trigger could occur if a photo detector improperly interprets a lighting flash as the beginning of daylight. In actual practice, this extended delay can become very important

because if the lamp is inadvertently de-energized too soon, it requires a substantial amount of time to reenergize the lamp (for example, ten minutes). After step 1428, the method proceeds to step 1422, which executes a Debounce Delay, and then returns to step 1410 as shown in Figures 19A and 19B.

Figure 19C shows a method for transmitting monitoring data multiple times from a monitoring and control unit 510, according to a further embodiment of the invention. This method is particularly important in applications in which the monitoring and control unit 510 does not have a RX unit 540 for receiving acknowledgments of transmissions.

The method begins with a transmit start block 1482 and proceeds to step 1484, which involves initializing a count value, i.e. setting the count value to zero. The method proceeds to step 1486, which involves setting a variable x to a value associated with a serial number of the monitoring and control unit 510. For example, the variable x may be set to 50 times the lowest nibble of the serial number.

The method proceeds to step 1488, which involves waiting a reporting start time delay associated with the value x. The reporting start time is the amount of delay time before the first transmission. For example, this delay time may be set to x seconds where x is an integer between 1 and 32,000 or more. This example range for x is particularly

useful in the street lamp application since it distributes the packet reporting start times over more than eight hours, approximately the time from sunset to sunrise.

The method proceeds to step 1490, in which a variable y representing a channel number is set. For example, y may be set to the integer value of RTC/12.8, where RTC represents a real time clock counting from 0-255 as fast as possible. The RTC may be included in the processing and sensing unit 520.

The method proceeds to step 1492, in which a packet is transmitted on channel y. The method then proceeds to step 1494, in which the count value is incremented. The method proceeds to step 1496, which is a decision block to determine if the count value equals an upper limit N.

If the count is not equal to N, the method returns from step 1496 to step 1488 and waits another delay time associated with the variable x. This delay time is the reporting delta time since it represents the time difference between two consecutive reporting events. If, at step 1496, it is determined that the count is equal to N, the method proceeds to step 1498 which is an end block.

The value for N must be determined based on the specific application. Increasing the value of N decreases the probability of a unsuccessful transmission since the same data is being sent multiple times and the probability of all of the packets being lost decreases as N increases. However, increasing the value of N also increases the amount of data

transmission traffic, which may become an issue in a monitoring and control system with a large number of monitoring and control units.

Figure 19D shows a method for transmitting monitoring data multiple times in a monitoring and control system according to another embodiment of the invention.

The method begins with a transmit start block 1810 and proceeds to step 1812, which involves initializing a count value, i.e., setting the count value to 1. The method proceeds to step 1814, which involves randomizing the reporting start time delay. The reporting start time delay is the amount of time delay required before the transmission of the first data packet. A variety of methods can be used for this randomization process, such as selecting a pseudo-random value or basing the randomization on the serial number of the monitoring and control unit 510.

The method proceeds to step 1816, which involves checking to see if the count equals 1. If the count is equal to 1, then the method proceeds to step 1820, which involves setting a reporting delta time equal to the reporting start time delay. If the count is not equal to 1, the method proceeds to step 1818, which involves randomizing the reporting delta time. The reporting delta time is the difference in time between each reporting event. A variety of methods can be used for randomizing the reporting delta time including selecting a pseudo-random value or selecting a random number based upon the serial number of the monitoring and control unit 510.

After either step 1818 or step 1820, the method proceeds to step 1822, which involves randomizing a transmit channel number. The transmit channel number is a number indicative of the frequency used for transmitting the monitoring data. There are a variety of methods for randomizing the transmit channel number such as selecting a pseudo-random number or selecting a random number based upon the serial number of the monitoring and control unit 510.

The method proceeds to step 1824, which involves waiting the reporting delta time. It is important to note that the reporting delta time is the time which was selected during the randomization process of step 1818 or the reporting start time delay selected in step 1814 (if the count equals 1). The use of separate randomization steps 1814 and 1818 is important because it allows the use of different randomization functions for the reporting start time delay and the reporting delta time, respectively.

The method then proceeds to step 1826, which involves transmitting a data packet on the transmit channel selected in step 1822.

The method proceeds to step 1828, which involves incrementing the counter for the number of packet transmissions.

The method proceeds from step 1828 to step 1830, in which the count is compared with a value N, which represents the maximum number of transmissions for each data packet. If the count is less than or equal to N, then the method proceeds from step 1830

back to step 1818 which involves randomizing the reporting delta time for the next transmission. If the count is greater than N, then the method proceeds from step 1830 to the end block 1832 for the transmission method.

In other words, the method will continue transmission of the same packet of data N times, with randomization of the reporting start time delay, randomization of the reporting delta times between each reporting event, and randomization of the transmit channel number for each packet. These multiple randomizations help stagger the data packets of multiple transmitters, in the frequency and time domain, to reduce the probability of collisions of data packets from different monitoring and control units.

Figure 19E shows an alternative method for transmitting monitoring data multiple times from a monitoring and control unit 510, according to another embodiment of the invention.

The method begins with a transmit start block 1840 and proceeds to step 1842, which involves initializing a count value, i.e., setting the count value to 1. The method proceeds to step 1844, which involves reading an indicator, such as a group jumper, to determine which group of frequencies to use, Group A or B. Examples of Group A and Group B channel numbers and frequencies can be found in Figure 11.

The method then proceeds to step 1846, where a decision is made as to whether Group A or B is being used. If Group A is being used, the method proceeds to step 1848

which involves setting a base channel to the appropriate frequency for Group A. If Group B is to be used, the method proceeds to step 1850, which involves setting the base channel frequency to a frequency for Group B.

After either step 1848 or step 1850, the method proceeds to step 1852, which involves randomizing a reporting start time delay. For example, the randomization can be achieved by multiplying the lowest nibble of the serial number of the monitoring and control unit 510 by 50 and using the resulting value, x, as the number of milliseconds for the reporting start time delay.

The method proceeds to step 1854, which involves waiting x number of seconds as determined in step 1852.

The method proceeds to step 1856, which involves setting a value z = 0, where the value z represents an offset from the base channel number set in step 1848 or 1850. The method then proceeds to step 1858, which determines whether the count equals 1. If the count equals 1, the method proceeds to step 1872, which involves transmitting the packet on a channel determined from the base channel frequency selected in either step 1848 or step 1850, plus the channel frequency offset selected in step 1856.

If the count is not equal to 1, then the method proceeds from step 1858 to step 1860, which involves determining whether the count is equal to N, where N represents the maximum number of packet transmissions. If the count is equal to N, then the

method proceeds from step 1860 to step 1872, which involves transmitting the packet on a channel determined from the base channel frequency selected in either step 1848 or step 1850 plus the channel number offset selected in step 1856.

If the count is not equal to N, indicating that the count is a value between 1 and N, then the method proceeds from step 1860 to step 1862, which involves reading a real time counter (RTC) which may be located in the processing and sensing unit 412.

The method proceeds from step 1862 to step 1864, which involves comparing the RTC value against a maximum value, for example, a maximum value of 152. If the RTC value is greater than or equal to the maximum value, then the method proceeds from step 1864 to step 1866 which involves waiting x seconds and returning to step 1862.

If the value of the RTC is less than the maximum value, then the method proceeds from step 1864 to step 1868, which involves setting a value y equal to a value indicative of the channel number offset. For example, y can be set to an integer of the real time counter value divided by 8, so that y value would range from 0 to 18.

The method proceeds from step 1868 to step 1870, which involves computing a frequency offset value z from the channel number offset value y. For example, if a 25 KHz channel is being used, then z is equal to y times 25 KHz.

The method then proceeds from step 1870 to step 1872 which involves transmitting the packet on a channel determined from the base channel frequency selected in either step 1848 or step 1850, plus the channel frequency offset computed in step 1870.

The method proceeds from step 1872 to step 1874, which involves incrementing the count value. The method proceeds to step 1876, which involves comparing the count value to a value N + 1, which is related to the maximum number of transmissions for each packet. If the count is not equal to N + 1, the method proceeds from step 1876 back to step 1854, which involves waiting x number of milliseconds. If the count is equal to N + 1, the method proceeds from step 1876 to the end block 1878.

The method shown in Figure 19E is similar to that shown in Figure 19D, but differs in that it requires the first and the Nth transmission to occur at the base frequency rather than a randomly selected frequency.

An alarm monitoring and control system and method according to one embodiment of the invention will now be described with reference to Figures 20-27.

Figure 20 shows an alarm monitoring and control unit 1510, according to one embodiment of the invention, having a processing unit 1520, a TX unit 1530, and an RX unit 1540. The processing unit 1520 is coupled to the TX unit 1530 for transmitting data to a base station. The processing unit 1520 is also coupled to a RX unit 1540 for receiving data either from the base station or from a remote unit such as an alarm unit. As an

option, the alarm monitoring and control unit 1510 can also include a second RX unit 1550 for receiving data either from the base station or from a remote device such as an alarm unit.

As another option, the alarm monitoring and control unit 1510 can include a sensing unit 1560 and a remote device 1570 both coupled to the processing unit 1520. For example, the sensing unit 1560 and the remote device 1570 can be for lamp monitoring and control so that the alarm monitoring and control unit 1510 can perform the functions of lamp and alarm monitoring and control.

Figure 21 shows an alarm monitoring and control unit 1610, according to an additional embodiment of the invention, having a processing unit 1620, a TX unit 1630, an RX unit 1640, and an imaging unit 1680. The alarm monitoring and control unit 1610 is similar to the alarm monitoring control unit 1510 in that it includes a processing unit 1620, a TX unit 1630, a RX unit 1640, an optional RX unit 1650, and an optional sensing unit 1660. These elements have functions analogous to the corresponding elements in Figure 20.

Additionally, the alarm monitoring and control unit 1610 includes an imaging unit 1680 coupled to the processing unit 1620. The imaging unit 1680 allows imaging to be performed based upon signals received from remote alarm units (not shown). For example, if an alarm signal is received from a remote alarm unit, the imaging unit 1680

can perform imaging of the local area in order to collect information which may be valuable to the police and other law enforcement agencies.

The imaging unit 1680 may be any form of imaging unit such as a still camera, a video camera, a low light level camera, or an infrared camera. The imaging unit 1680 also can include a wide variety of lens types such as a wide field of view lens to enable a very broad field of view during surveillance. The imaging unit 1680 can also include a pointing device which allows the imaging unit 1680 to point at different objects depending on the source of the alarm. Although the imaging unit 1680 is shown inside the alarm monitoring and control unit 1610, the imaging unit 1680 may be included in the same housing as the processing unit 1620 or may be included in a separate housing with some form of communication link between the imaging unit 1680 and the processing unit 1620.

The alarm monitoring and control unit 1610 can also include one or more optional additional imaging units 1685. The optional imaging unit 1685 could be pointed in a direction different from the imaging unit 1680. As previously described, the optional imaging unit 1685 can also be implemented using a variety of different forms of imaging units such as a still camera, video camera, low light level TV, low light level video camera, and infrared video camera. Also, as previously discussed, the alarm monitoring and control unit 1610 can include an optional sensing unit 1660 and could be connected to a

remote device 1670 to allow both lamp monitoring and alarm monitoring in one monitoring and control unit.

Figure 22 shows an alarm monitoring and control unit 1710, according to another embodiment of the invention, having a processing unit 1720, a TX unit 1730, an RX unit 1740, an imaging unit 1780, an interface 1790, and a memory 1795.

The alarm monitoring and control unit 1710 is similar to the alarm monitoring and control unit 1610 in terms of the inclusion of a processing unit 1720, a TX unit 1730, a RX unit 1740, an imaging unit 1780, and optional elements such as the RX unit 1750, the sensing unit 1760, and the optional imaging unit 1785. In addition, the alarm monitoring and control unit 1710 includes an interface 1790 and a memory 1795, both of which are coupled to the processing unit 1720. The memory 1795 allows storage of information at the alarm monitoring and control unit 1710. For example, if the imaging unit 1780 collects image data, that image data can be stored in the memory 1795 for download at a later time. The interface 1790 is the mechanism through which the download of information, such as image data, from the memory 1795 is conducted. The interface 1790 can be implemented in a variety of ways, such as through use of a wired line, infrared link, fiber optic link, or RF link. In addition, it is well known to those skilled in the art that there are many ways for implementing the memory 1795 such as use of DRAM, SRAM, flash RAM, etc.

Figure 23 shows an alarm unit 1810, according to a preferred embodiment of the invention, having an alarm detection unit 1820 and a TX unit 1830. The alarm detection unit 1820 detects an alarm condition, and the TX unit 1830, which is coupled to the alarm detection unit 1820, transmits associated alarm information to an the alarm monitoring and control unit such as the alarm monitoring control units 1510, 1610 or 1710. The alarm unit 1810 can take a variety of different forms depending on the particular application. For example, in a residential house or a commercial building, the alarm unit 1810 can be part of an alarm system so that the alarm detection unit 1820 is coupled to alarm sensors which detect an alarm condition. Some examples of alarm conditions are the opening of a door or window or the detection of motion in a particular room of a building.

In other applications, the alarm detection unit 1820 can be coupled to an alarm panic button. For example, an alarm panic button could be installed in vehicles such as taxicabs so that in the event of a robbery, the taxicab driver could push the alarm panic button producing an alarm detection signal in an alarm detection unit 1820 which results in the associated alarm information being transmitted by the TX unit 1830. The concept of alarm panic buttons can also be used in fixed locations such as in a commercial location like a bank or an ATM machine. The panic button could also be placed in public areas such as on lamp posts along the side of a highway.

The alarm condition which triggers the alarm detection unit 1820 is not limited to robberies, but also can include other forms of alarm conditions such as detection of fire or flooding in a building.

Figure 24 shows an alarm unit 1910, according to another embodiment of the invention, having an alarm detection unit 1920, a TX unit 1930, a processing unit 1940, and an imaging unit 1950.

The processing unit 1940 is coupled to the alarm detection unit 1920, the TX unit 1930, and the imaging unit 1950. The alarm unit 1910 can be used for all of the applications described with respect to the alarm unit 1810. In addition, the alarm unit 1910 includes the processing unit 1940 and the imaging unit 1950, which allows it to perform additional applications in which image data is required at the location of the alarm unit 1910. As an example of one such application, if a residence is broken into, the alarm system would send an alarm signal to the alarm detection unit 1920. In response to this alarm signal, the alarm detection unit 1920 would send a signal to the processing unit 1940, which would in turn begin operation of the imaging unit 1950. The imaging unit 1950 could then surveil the area in a variety of ways similar to the imaging units 1680 and 1780. That is, the imaging unit 1950 can collect photographic still data, video data, low light level video data, or infrared data. Furthermore in some applications, the image data could include audio data collected by the same imaging unit.

The alarm unit 1910 can also include an optional memory 1960 and an interface 1970 to allow local storage of the image data from the imaging unit 1950. In an application in which local storage is selected, the TX unit 1930 will transmit out an alarm indication signal to an alarm monitoring control unit to indicate an alarm condition has been detected at the alarm unit 1910. In other applications, image data from the imaging unit 1950 can be directly transmitted using the TX unit 1930.

Figure 25 shows an interrogation unit 2010 having a processing unit 2030, an interface 2020, and a storage unit 2040, according to one embodiment of the invention.

The interface unit 2020 and the storage unit 2040 are both coupled to the processing unit 2030. The interrogation unit 2010 allows for downloading of data from memory units in either the alarm monitoring and control unit 1710 or the alarm unit 1910. For example, referring back to the alarm unit 1910 shown in Figure 24, if image data is stored in the memory 1960, then the interrogation unit 2010 can download that data by establishing communication between the interface 1970 and the interface 2020. The information is then sent through the processing unit 2030 to the storage unit 2040 for later retrieval. A similar interrogation unit 2010 can be used with the alarm monitoring and control unit 1710 as shown in Figure 22.

For example, if image data is stored in the memory 1795 at the alarm monitoring and control unit 1710, then the interrogation unit 2010 can download this image data via

a communication link established between the interface 1790 and the interface 2020. The communication link between the interface 1790 and the interface 2020 can take a variety of forms well known to those skilled in the art such as wire, infrared, fiber optic, or RF. Likewise, the storage unit 2040 can be implemented in a variety of ways such as using DRAM, SRAM, flash RAM, floppy disks, hard disks, video tape, streaming tape, etc.

Figure 26 shows an alarm monitoring and control system 2100, according to one embodiment of the invention, having a main station 710 coupled through communication links to a plurality of base stations 610a-b.

The main station 710 and the base stations 610a and 610b are analogous in function to the similar elements in Figures 9 and 10, which were described with respect to Figure 17. Each base station 610a and 610b is coupled to a variety of monitoring and control units (MCU) 2110a-d. The MCUs 2110a-d are further coupled to a variety of alarm units. For example, a residential building 2120 may include an alarm unit 2120a. As previously discussed, the alarm unit 2120a detects an alarm signal and transmits associated alarm information to the MCU 2110a.

In other embodiments, the alarm unit can be in a commercial building 2120′ or an industrial building 2120′′. The commercial building 2120′ includes an alarm unit 2120′a, which is similar in function to alarm unit 2120a. Likewise, industrial site 2120′′ includes an alarm unit 2120′′a, which is similar in function to the alarm unit 2120a. As

another example, an automobile 2130 can be equipped with an alarm unit 2130a. As previously discussed, the alarm unit 2130a can include a panic button. For example, the alarm unit 2130a would allow a taxi driver to press the panic button in the event of a robbery. Pressing the panic button on the alarm unit 2130a would result in a signal being sent to MCU 2110a which would further send a signal to base station 610a, which in turn would send a signal to the main station 710. Likewise, panic buttons can be installed at other locations, such as a panic button 2150a installed in a building 2150 or a panic button 2140a installed at a lamp post 2140 or in a public place.

If a real time response is required, the alarm information transmitted from an alarm unit such as the alarm unit 2130a is relayed through the MCU 2110a to the base station 610a and further to the main station 710. The alarm information at the main station 710 can include at least the unique ID for the alarm unit 2130a and the ID of the MCU 2110a which relayed the alarm information. The alarm information can include a time stamp indicating the time that the alarm unit 2130a transmitted the alarm information. Alternatively, the time stamp can be the time that alarm information is received at the MCU 2110a, at the base station 610a or at the main station 710. This alarm information can be relayed directly to the police to alert law enforcement agencies that a robbery is in progress in a particular taxicab in a particular neighborhood. Additionally, the alarm information can be stored in a database at the main station 710 or another location and

can be used by either law enforcement agencies or insurance agencies to analyze crime data in a neighborhood. For example, if a law enforcement agency recognizes that the crime rate during a specific time of day is high in a particular neighborhood based upon the alarm information relayed from alarm units, the law enforcement agency can increase patrols in that area to reduce the criminal activity.

Figure 27 shows the steps of a method 2200, according to another embodiment of the invention, for monitoring and controlling an alarm.

The method includes a detecting step 2210, which involves detecting that an alarm condition has occurred. The method proceeds to a transmitting step 2220, which involves transmitting alarm information associated with the alarm condition detected in detecting step 2210.

The method proceeds to a further transmitting step 2230, which involves transmitting alarm data from an MCU to a base station.

The method 2200 proceeds to an analyzing step 2240, which involves analyzing the alarm data. As previously discussed, the step of analyzing the alarm data can take several forms such as storage for later processing or the forwarding of the alarm data to proper law enforcement activities for real-time response. The alarm data can also take a variety of forms and can include the ID numbers for the associated alarm unit and monitoring and control unit, a time stamp, and an indication of the type of alarm such as a fire alarm

or a burglar alarm. Additionally, the alarm data may include image data relayed from an imaging device, such as an imaging device located in the alarm unit or in the alarm monitoring and control unit. Analyzing step 2240 can also include statistical analysis in a database. It is well known to those skilled in the art that such a database can be created with a variety of commercially available programs such as Oracle, Sybase, SQL server, Access, etc.

The foregoing embodiments are merely exemplary and are not to be construed as limiting the present invention. The present teaching can be readily applied to other types of apparatus. The description of the present invention is intended to be illustrative, and not to limit the scope of the claims. Many alternatives, modifications, and variations will be apparent to those skilled in the art.

WHAT IS CLAIMED IS:

1. A lamp monitoring and control unit comprising:

a control unit for sensing at least one parameter of an associated lamp; and

a transmit unit for transmitting the sensed parameter data and lamp identification data to a base station when a condition of the lamp changes.

2. The lamp monitoring and control unit of claim 1, further comprising a light sensor, coupled to said control unit, detects an amount of ambient light and that outputs a light signal associated with the detected of ambient light to said control unit.

3. The lamp monitoring and control unit of claim 2 , wherein the control unit controls an operation of the lamp based on the light signal from the light sensor.

4. The lamp monitoring and control unit of claim 1, wherein said control unit is coupled to an associated lamp via a standard three prong twist-lock plug interface.

5. The lamp monitoring and control unit of claim 1, wherein the control unit includes a current sensor for sensing a current applied to an associated lamp.

6. The lamp monitoring and control unit of claim 1, wherein the control unit includes a voltage sensor for sensing a voltage applied to an associated lamp.

7. The lamp monitoring and control unit of claim 1, wherein said transmit unit includes a transmitter and a modified directional discontinuity ring radiator having a plurality of loops for resonance at a desired frequency range.

8. The lamp monitoring and control unit of claim 1, further comprising a receiver that receives lamp control data, wherein the receiver is coupled to the control unit, and wherein the control unit controls an operation of an associated lamp based on the lamp control data.

9. A method for monitoring and controlling a lamp comprising the steps of:

detecting an amount of ambient light;

controlling a lamp based on the detected ambient light;

sensing at least one lamp parameter of the lamp; and

transmitting the sensed parameter data and lamp identification data to a central location when a state of the lamp changes.

10. The method of claim 9, wherein said sensing step includes sensing at least one of an electrical current and an electrical voltage applied to the lamp.

11. The method of claim 9, further comprising the steps of:

waiting for a delay period to elapse when a first detecting step indicates that an amount of ambient light has crossed a threshold value; and

performing a second detecting step after the delay period has elapsed.

12. The method of claim 11, wherein the controlling step comprises changing an operational state of the lamp when both the first and the second detecting steps indicate that the amount of ambient light has crossed the threshold value.

13. The method of claim 9, further comprising the step of waiting for a stabilization delay period to elapse after an operational state of the lamp changes before performing the sensing step.

14. The method of claim 9, further comprising a step waiting for a reporting delay period to elapse before performing the transmitting step.

15. The method of claim 14, further comprising a step of setting the reporting delay period based on one of a pseud-random process and a serial number.

16. The method of claim 9, further comprising the step of repeating the transmitting step a plurality of times to perform redundant transmissions.

17. The method of claim 16, wherein each of the redundant transmissions is transmitted on a pseudo-randomly selected frequency.

18. A system for monitoring and controlling a plurality of remote devices, comprising:

a plurality of control units, each coupled to at least one of the plurality of remote devices, wherein each of the control units transmit monitoring data having at least an ID field and a status field when a status of an associated remote device changes; and

at least one base station, coupled to a group of said control units, for receiving the monitoring data, wherein each base station includes an ID and status processing unit for processing the monitoring data.

19. The system of claim 18, wherein the ID field is configured to include a control unit identification number.

20. The system of claim 18, wherein the ID field is configured to include a base station identification number.

21. The system of claim 18, wherein the monitoring data further includes a data field.

22. The system of claim 21, wherein the data field is configured to include at least one of current data and voltage data related to one of the plurality of remote devices.

23. The system of claim 18, wherein at least one of said plurality of control units is configured to receive control information from said at least one base station.

24. The system of claim 18, wherein at least one of said plurality of control units transmits the monitoring data to the at least one base station via a radio frequency link.

25. The system of claim 24, wherein the radio frequency link is in a frequency range of approximately 218-219 MHZ.

26. The system of claim 18, wherein said at least one base station comprises a group of base stations coupled together in a network topology.

27. The system of claim 18, wherein said at least one base station comprises a plurality of base stations, and further comprising a main station coupled to the plurality of base stations, wherein the main station receives monitoring data from a plurality of control units through the plurality of base stations.

28. The system of claim 18, wherein the plurality of control units are configured to stagger their transmissions of monitoring data in at least one of frequency and time.

29. The system of claim 18, wherein at least one of the remote devices comprises an alarm device, and wherein at least one of the control units is coupled to the alarm device by a receiver for receiving an alarm signal from the alarm device.

30. The system of claim 29, wherein the at least one control unit coupled to the alarm device also includes an imaging unit for recording an image when the at least one control unit receives an alarm signal from the alarm device.

31. The system of claim 30, wherein the monitoring data transmitted by the at least one control unit coupled to the alarm device comprises image data recorded by the imaging unit.

32. The system of claim 29, wherein the at least one control unit coupled to the alarm device also receives image data from the alarm device, and wherein the monitoring data transmitted by the at least one control unit includes the image data received from the alarm device.

33. A base station for receiving monitoring data, including an ID field and a status field, from a plurality of remote devices, comprising:

a receive antenna system for receiving the monitoring data;

a receiving system front end, coupled to said receive antenna system, for outputting received monitoring data;

a multi-port splitter, coupled to said receiving system front end, for receiving the monitoring data and outputting a plurality of split monitoring data signals;

a plurality of receive modems, coupled to said multi-port splitter, wherein each receive modem receives and demodulates a split monitoring data signal and outputs a received data signal; and

a controller, coupled to said plurality of receive modems, wherein the controller is configured to receive received data signals and process identification and status data contained in the received data signals.

34. The base station of claim 33, further comprising a memory coupled to the controller, wherein the controller is also configured to store processed identification and status data in the memory.

35. The base station of claim 33, further comprising a transmit unit for transmitting processed identification and status data to a main station.

36. The base station of claim 33, further comprising a transmitter for outputting control information to a plurality of remote devices.

37. A method of monitoring and reporting the status of a remote device, comprising the steps of:

monitoring a status of a remote device; and

transmitting status and identification data regarding the remote device to a central location when a status of the remote device changes, wherein the transmitting step is performed a plurality of times in a pseudo-random fashion.

38. The method of claim 37, wherein the transmitting step comprises the steps of:

randomizing a reporting start delay time;

randomizing a reporting delta time; and

redundantly sending the status and identification data in accordance with the reporting start delay time and the reporting delta time.

39. The method of claim 37, wherein the transmitting step comprises the steps of:

selecting a transmission channel utilizing one of a random process, a pseudo-random process and a serial number; and

redundantly sending status and identification data on the selected transmission channel.

40. The method of claim 37, wherein the transmitting step comprises the sub-steps of:

selecting a transmission channel utilizing one of a random process, a pseudo-random process and a serial number; and

redundantly sending the status and identification data a first and a last time on a fixed transmission channel and all other times on the selected transmission channel.

41. An alarm monitoring and control system, comprising:

at least one alarm unit for detecting an alarm condition;

a transmit unit, coupled to said alarm unit, for transmitting alarm information related to an alarm condition; and

at least one relay unit including a receiver configured to receive alarm information from a plurality of alarm units, and a transmitter for transmitting the alarm information to a central location.

42. The system of claim 41, wherein said at least one alarm unit comprises:

an alarm detection unit for detecting an alarm condition; and

an imaging unit, coupled to said alarm detection unit, for recording image data, wherein the alarm information includes image data recorded by the imaging unit.

43. The system of claim 42, wherein each said at least one alarm unit further comprises a memory, coupled to the imaging unit, for storing image data recorded by the imaging unit.

44. The system of claim 41, wherein the at least one relay unit includes at least one imaging unit for recording image data.

45. The system of claim 44, wherein the alarm information transmitted from the relay unit to the central location includes image data recorded by the at least one imaging unit.

46. The system of claim 44, wherein the at least one imaging unit comprises a plurality of imaging units, wherein each imaging unit is configured to record image data from a different field of view.

47. The system of claim 41, wherein the at least one alarm unit comprises a panic button.

48. The system of claim 41, further comprising at least one base station for receiving the alarm information from the at least one relay unit.

49. The system of claim 48, further comprising a main station for receiving alarm information from the at least one base station.

50. A method for alarm monitoring, comprising the steps of:

detecting an alarm condition at an alarm unit;

transmitting alarm information, related to the alarm condition, from the alarm unit to a monitoring unit;

further transmitting alarm data, related to the alarm information, from the monitoring unit to a base station; and

analyzing the alarm data to determine a location of the alarm unit transmitting the alarm information.

51. The method of claim 50, further comprising a step of producing image data from an imaging unit at the alarm unit.

52. The method of claim 51, further comprising a step of interrogating the alarm unit to cause the alarm unit to transmit the image data produced at the alarm unit.

53. The method of claim 50, further comprising a step of producing image data from an imaging unit at the monitoring unit.

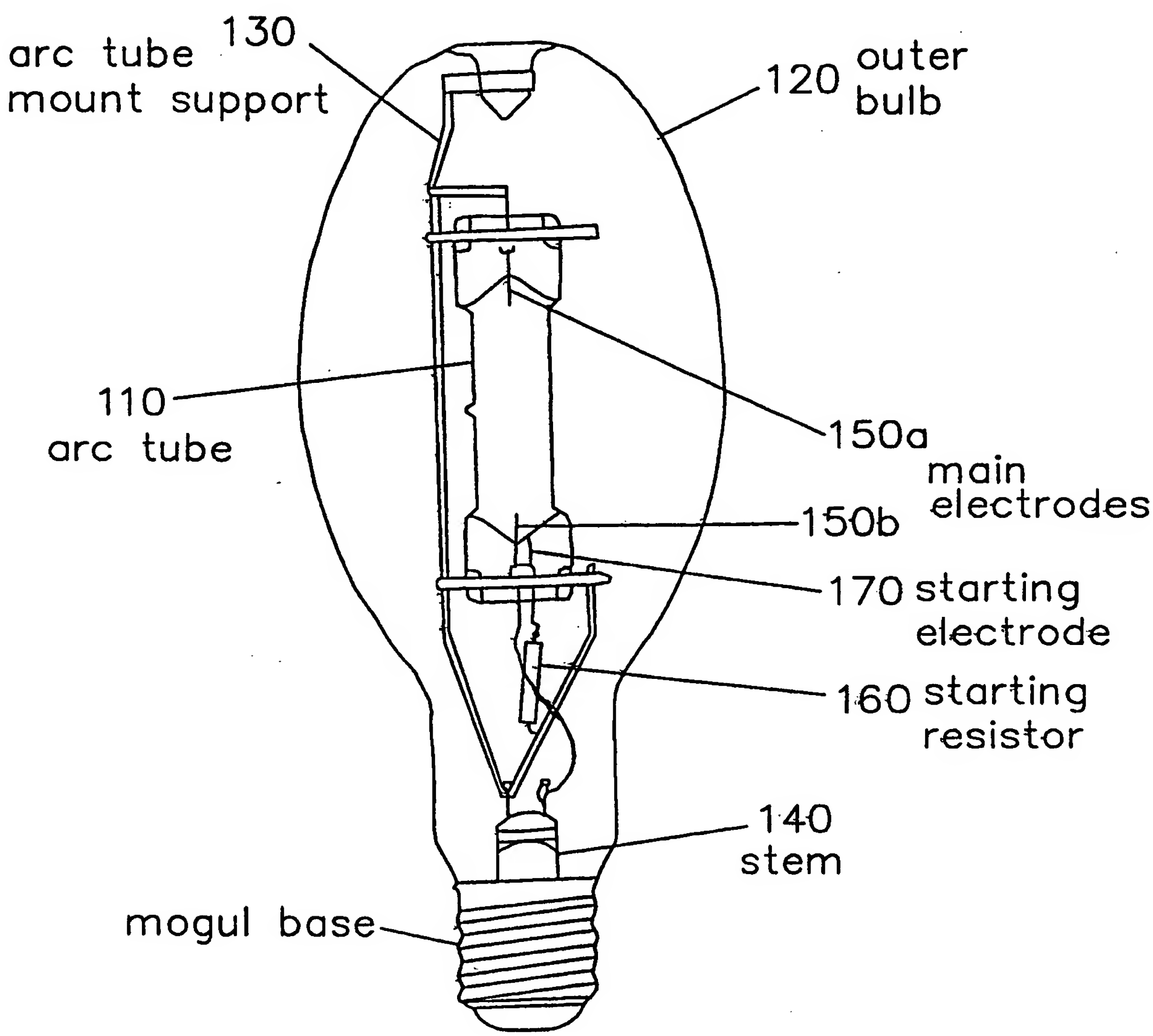
54. The method of claim 53, further comprising a step of interrogating the monitoring unit to cause the monitoring unit to transmit the image data.

55. A monitoring and control system comprising:

a plurality of alarm units for detecting an alarm condition; and

at least one monitoring and control unit, coupled to a group of said plurality of alarm units for receiving alarm information from the alarm units, wherein the at least one monitoring and control unit is also coupled to an associated street lamp to control operations of the street lamp based on ambient light conditions.

56. The system of claim 55, wherein the at least one monitoring and control unit also includes a transmitter configured to transmit alarm status data and street lamp data.



High-pressure mercury-vapor lamp

FIG. 1

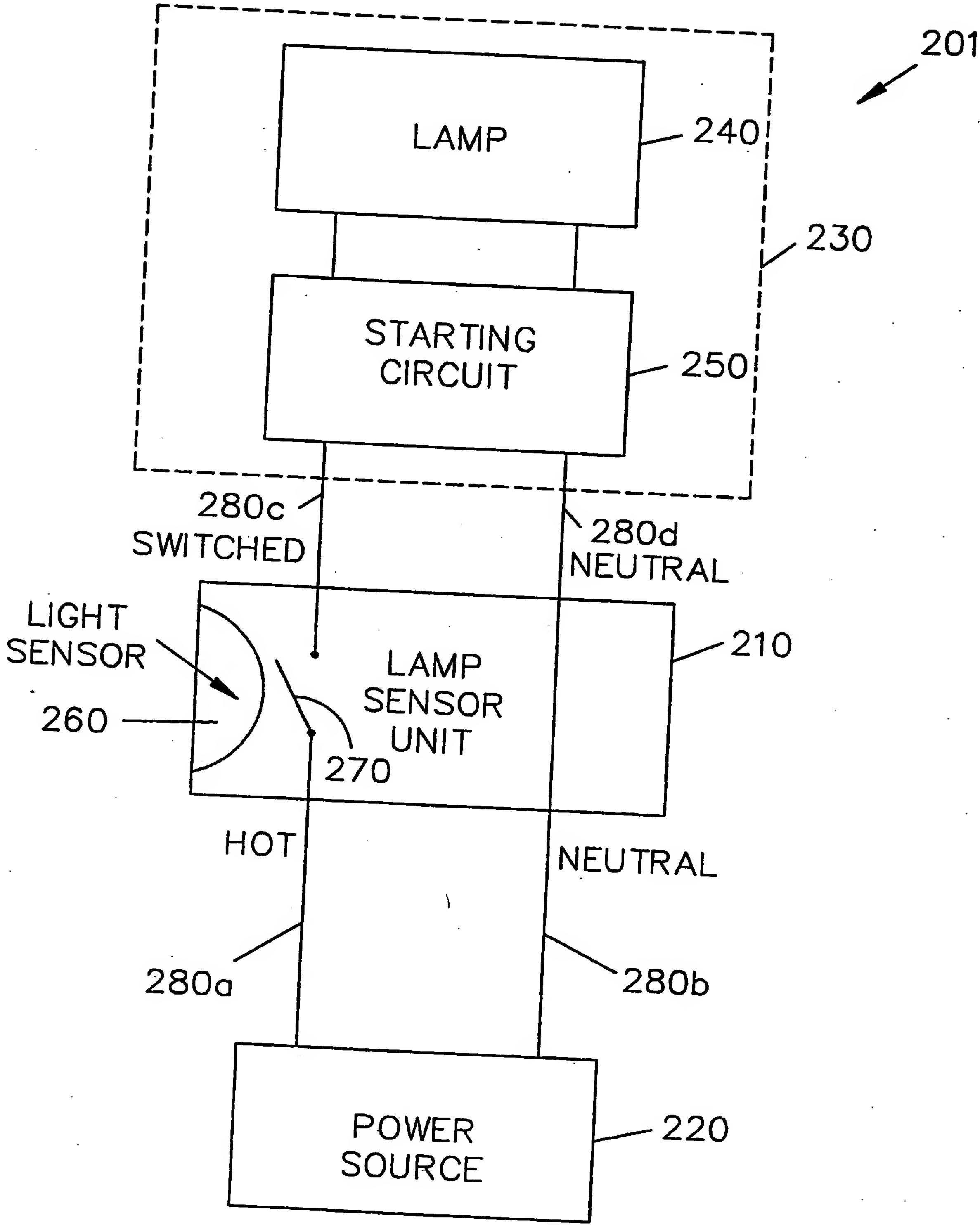

201
LAMP
240
230
STARTING
CIRCUIT
250
280c
SWITCHED
280d
NEUTRAL
LIGHT
SENSOR
260
LAMP
SENSOR
UNIT
270
210
HOT
NEUTRAL
280a
280b
POWER
SOURCE
220

FIG. 2

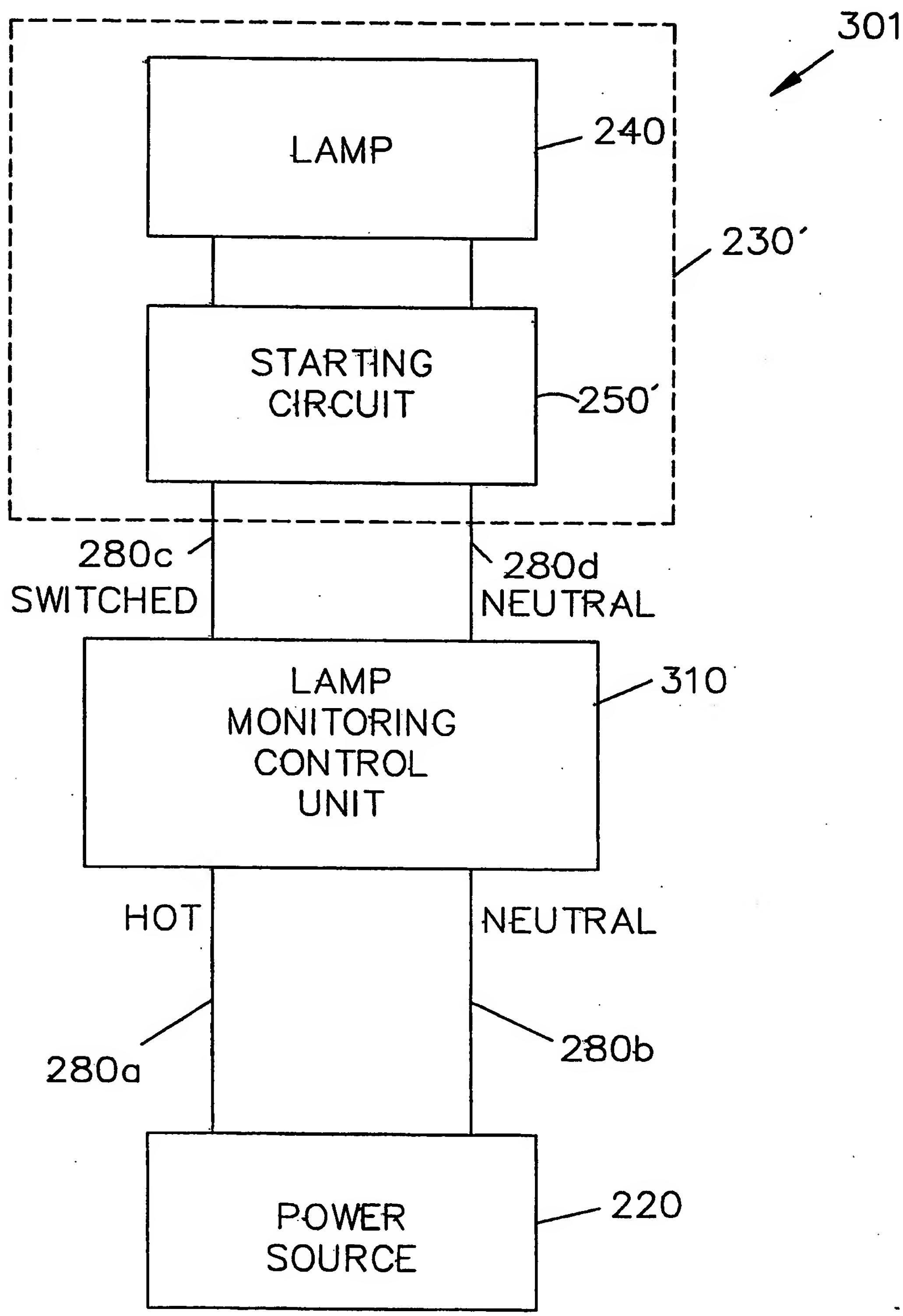

301
LAMP
240
230'
STARTING CIRCUIT
250'
280c
SWITCHED
280d
NEUTRAL
LAMP MONITORING CONTROL UNIT
310
HOT
NEUTRAL
280a
280b
POWER SOURCE
220

FIG. 3

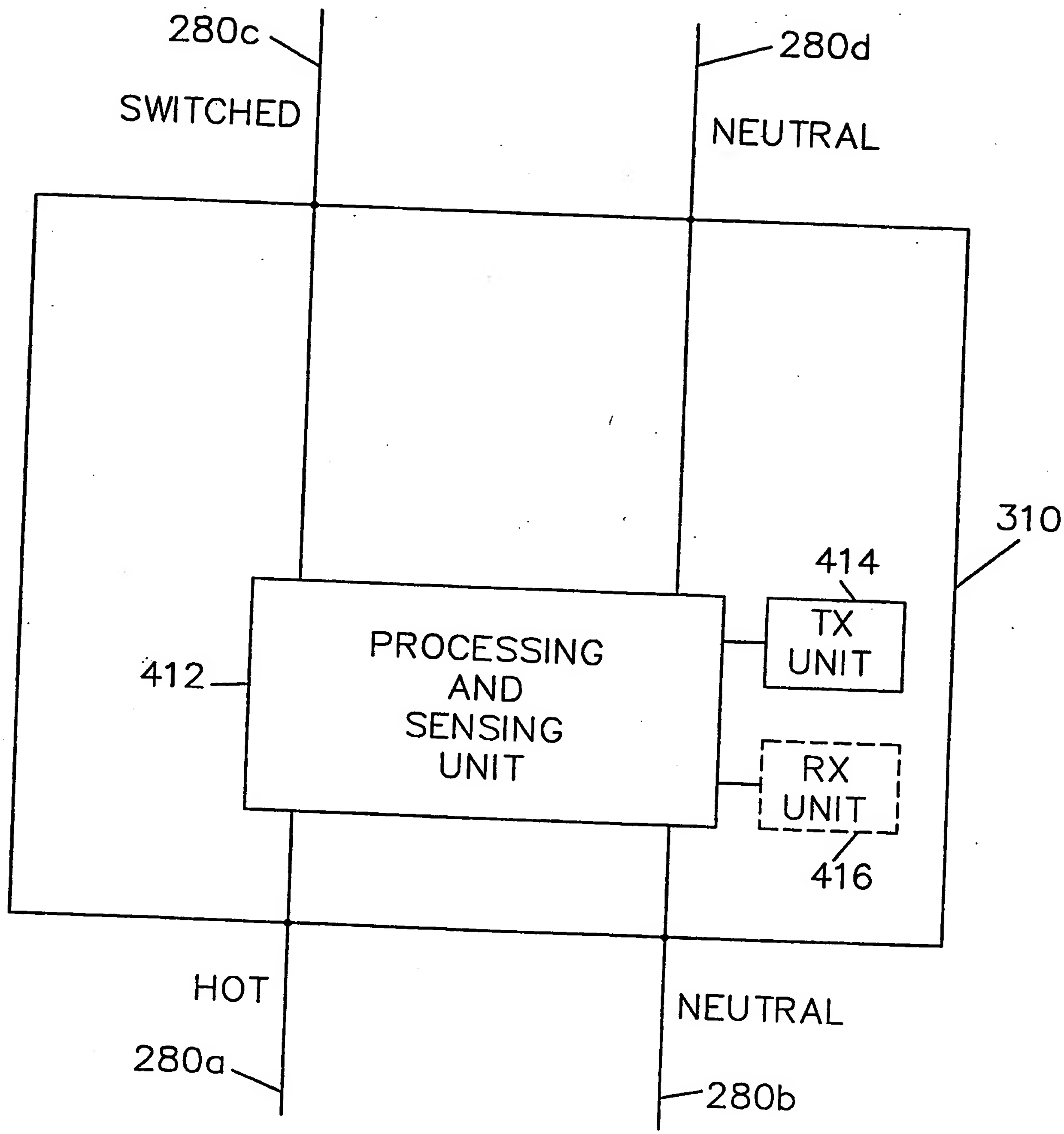

280c
SWITCHED
280d
NEUTRAL
310
414
TX UNIT
PROCESSING AND SENSING UNIT
412
RX UNIT
416
HOT
280a
NEUTRAL
280b

FIG. 4

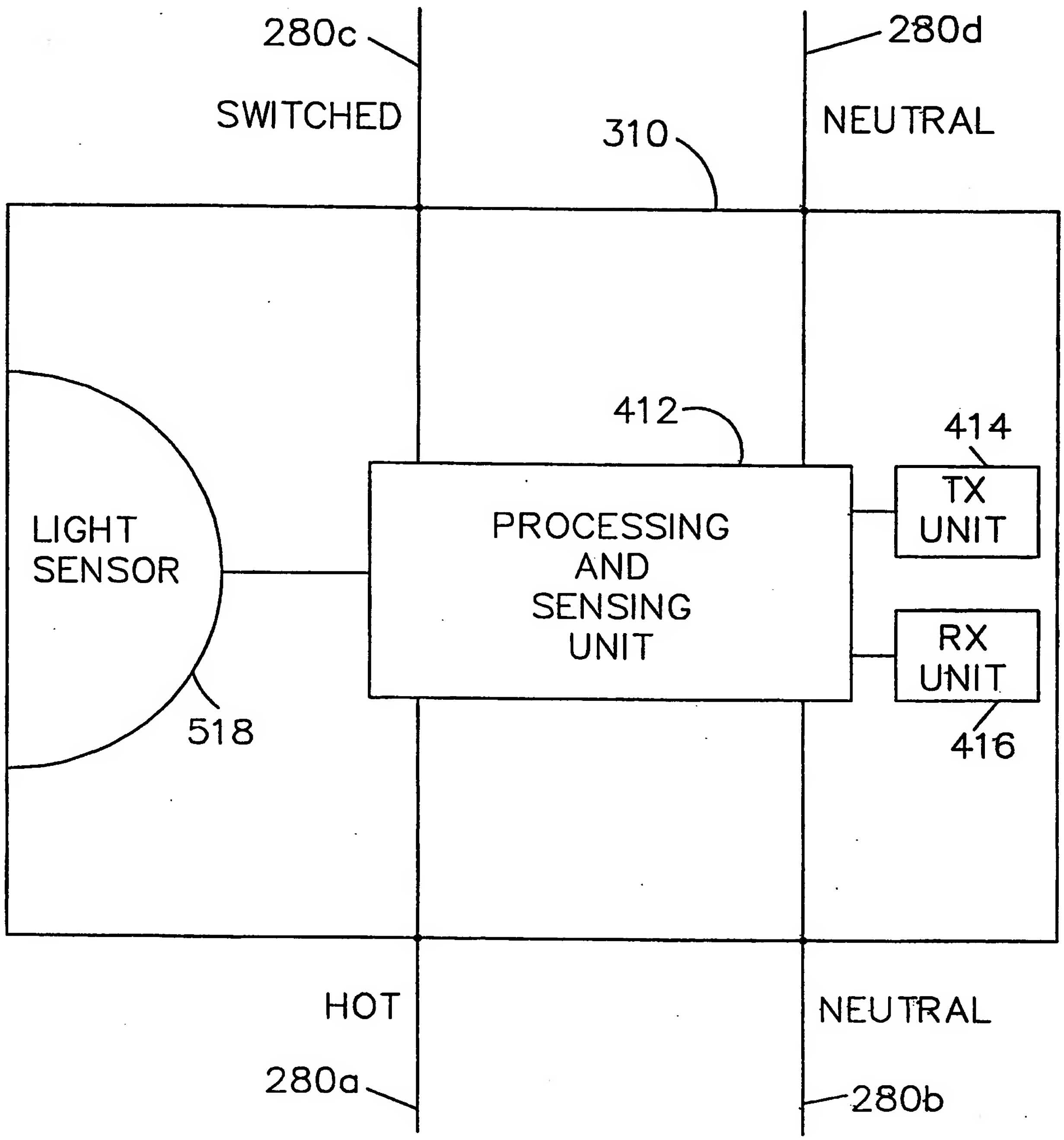

280c
280d
SWITCHED
310
NEUTRAL
412
414
TX UNIT
LIGHT SENSOR
PROCESSING AND SENSING UNIT
RX UNIT
518
416
HOT
NEUTRAL
280a
280b

FIG. 5

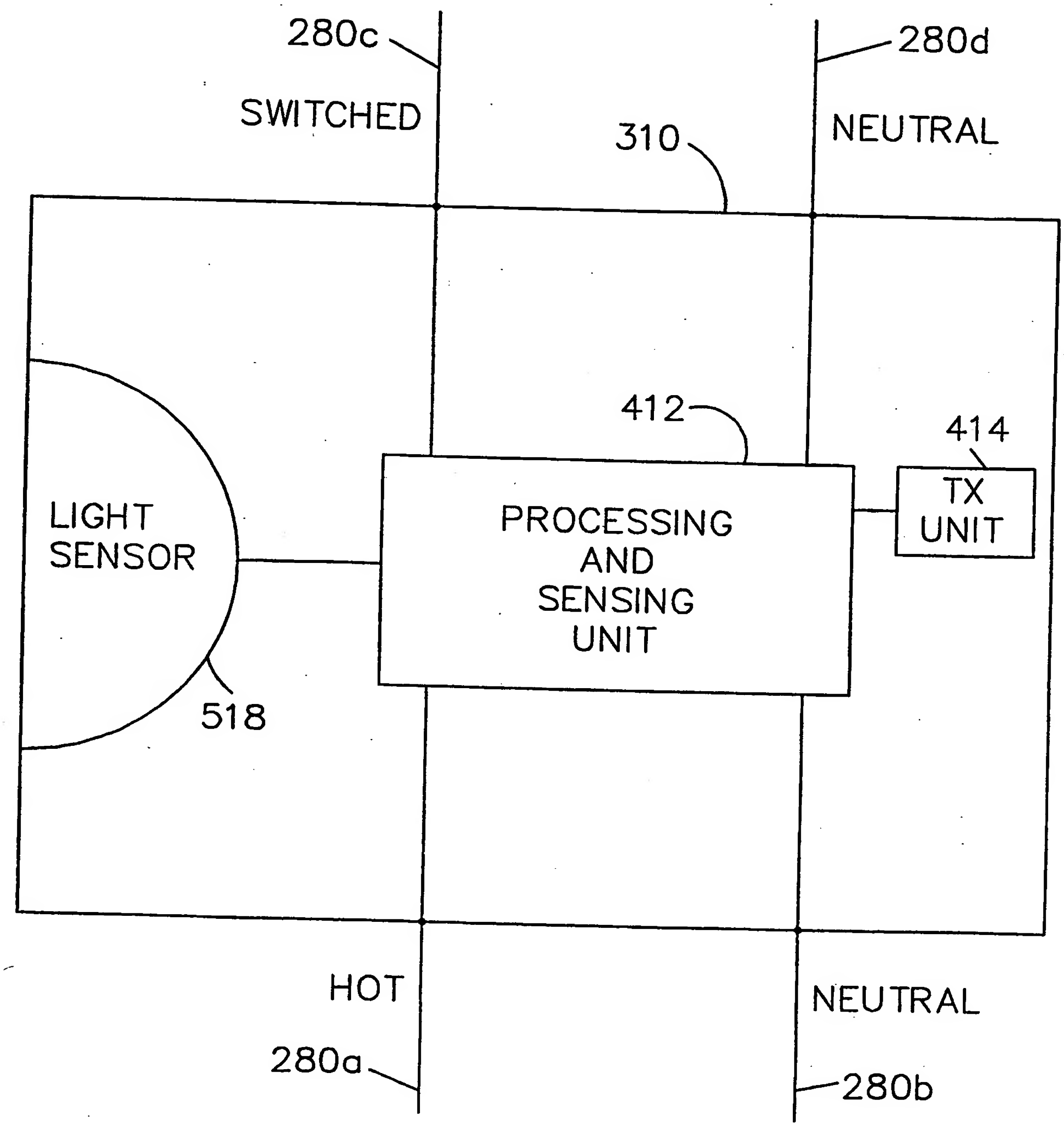

280c
SWITCHED
280d
NEUTRAL
310
412
414
TX
UNIT
LIGHT
SENSOR
PROCESSING
AND
SENSING
UNIT
518
HOT
NEUTRAL
280a
280b

FIG. 6

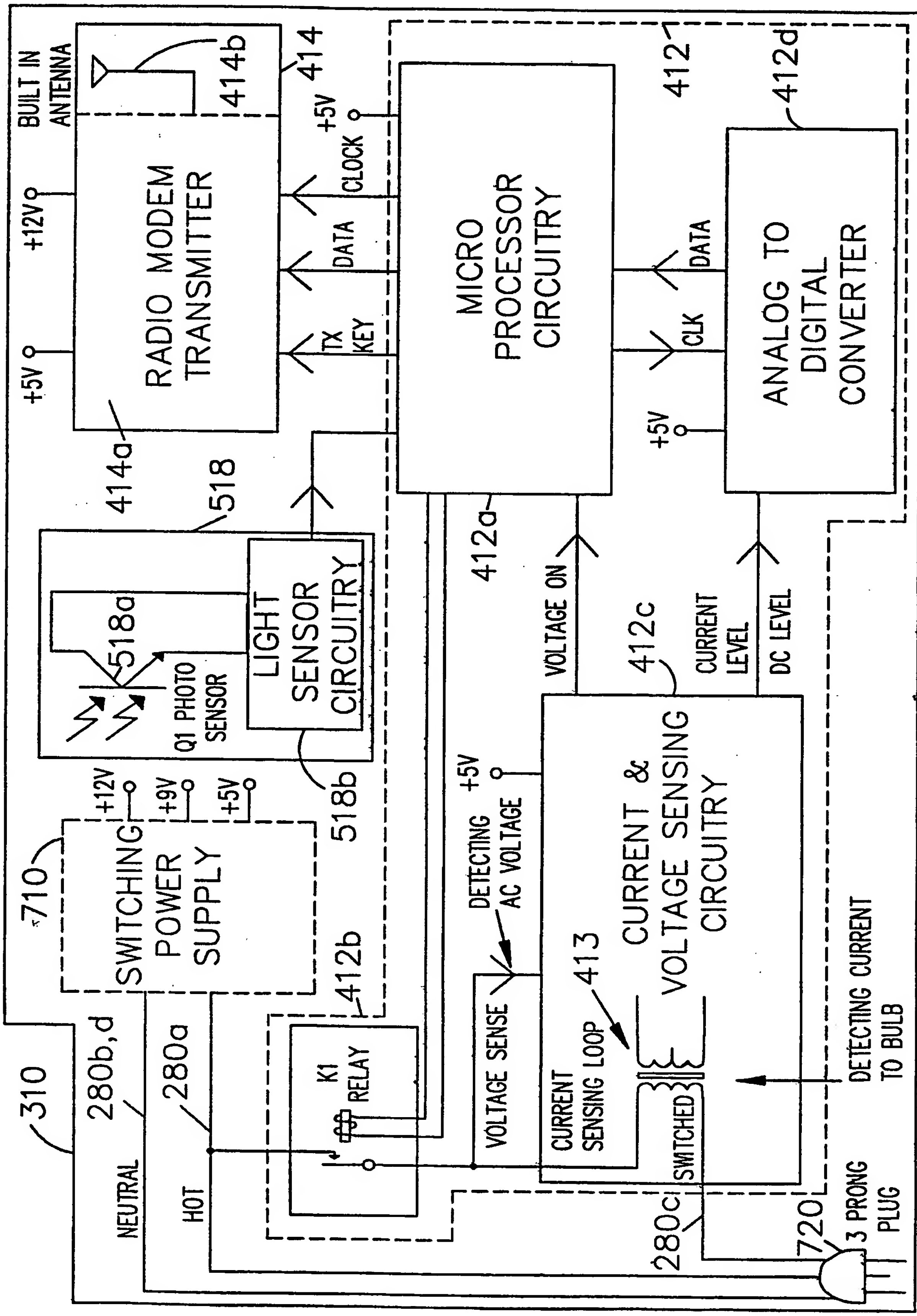

BUILT IN ANTENNA
414b
414
+12V
+5V
RADIO MODEM TRANSMITTER
+5V
CLOCK
DATA
TX KEY
414a
MICRO PROCESSOR CIRCUITRY
412
412d
DATA
CLK
+5V
ANALOG TO DIGITAL CONVERTER
518
518a
Q1 PHOTO SENSOR
LIGHT SENSOR CIRCUITRY
518b
412a
VOLTAGE ON
412c
CURRENT LEVEL
DC LEVEL
+12V
+9V
+5V
710
SWITCHING POWER SUPPLY
412b
+5V
DETECTING AC VOLTAGE
VOLTAGE SENSE
CURRENT & VOLTAGE SENSING CIRCUITRY
413
CURRENT SENSING LOOP
SWITCHED
DETECTING CURRENT TO BULB
K1 RELAY
310
280b,d
280a
NEUTRAL
HOT
280c
720
3 PRONG PLUG

FIG. 7

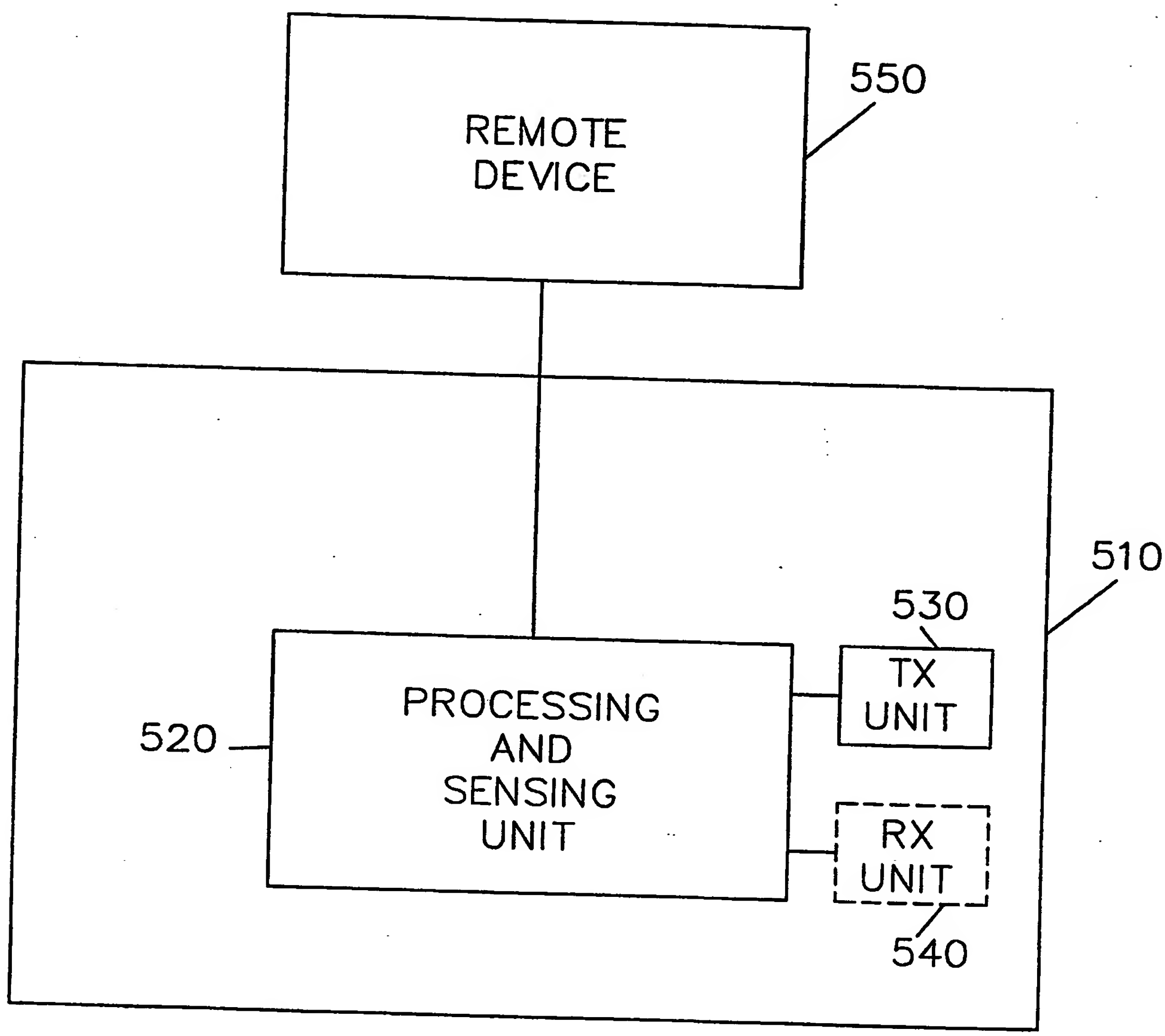

REMOTE DEVICE
550
510
530
TX UNIT
520
PROCESSING AND SENSING UNIT
RX UNIT
540

FIG. 8

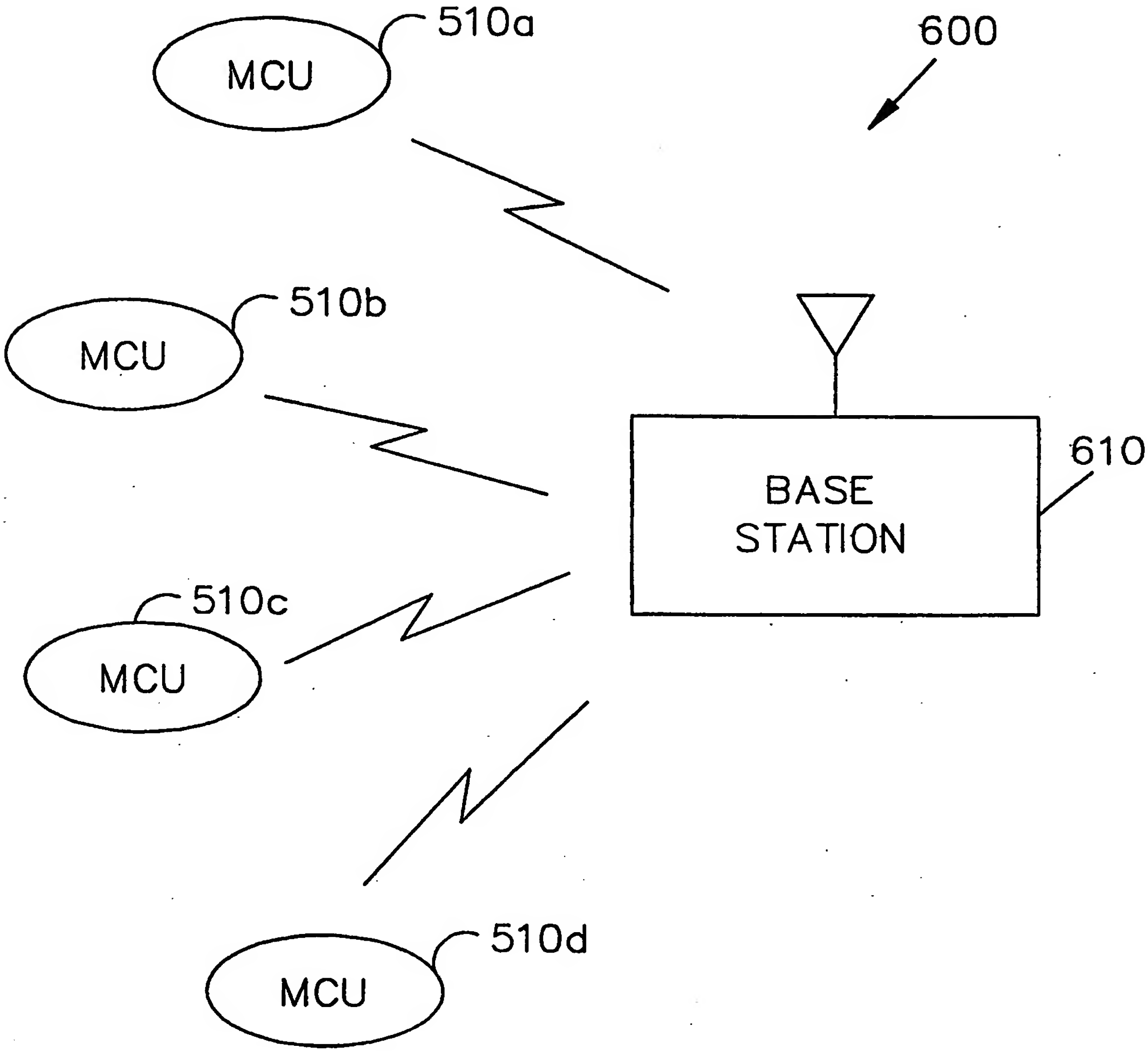


FIG. 9

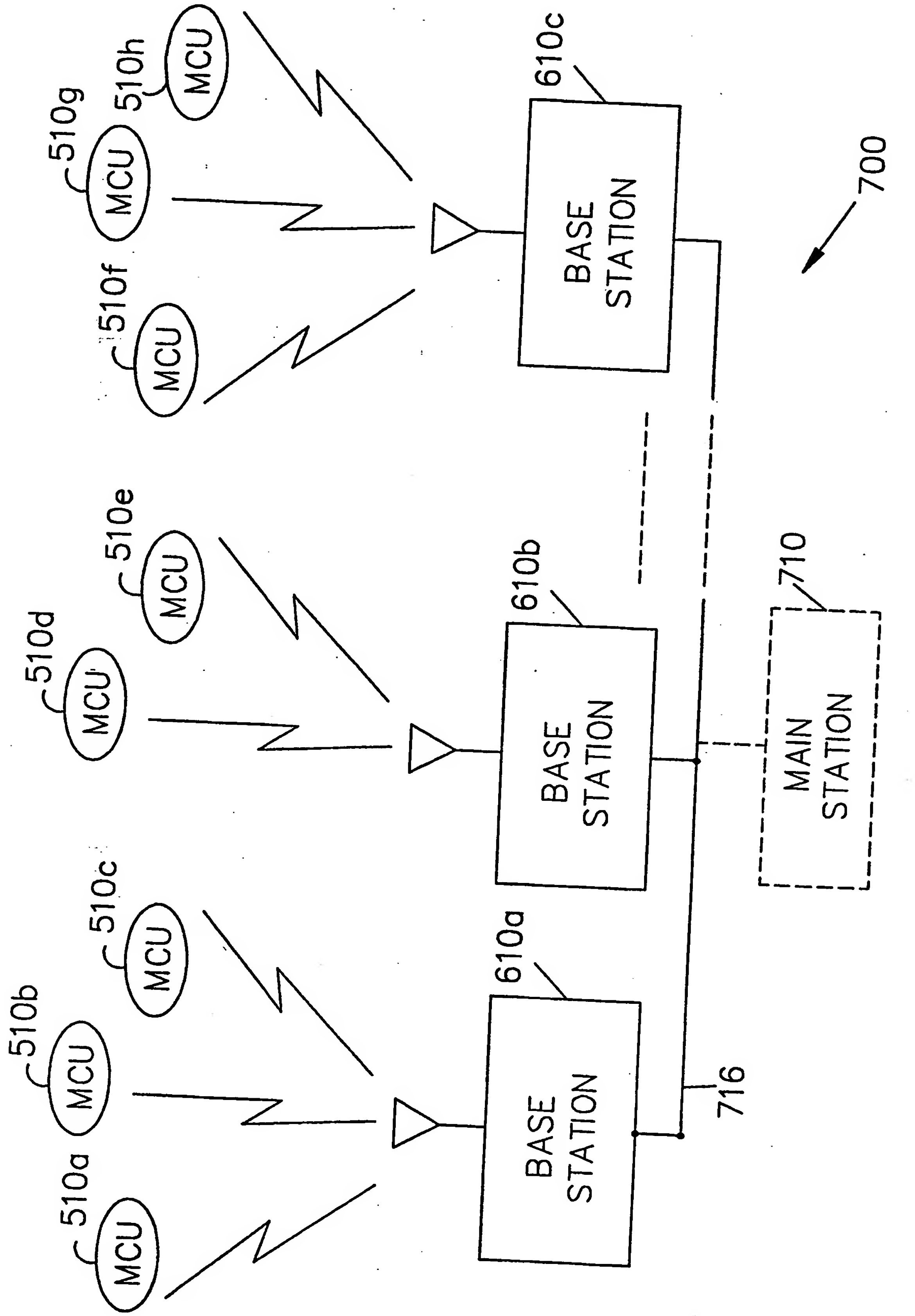

MCU
510a
MCU
510b
MCU
510c
BASE STATION
610a
MCU
510d
MCU
510e
BASE STATION
610b
MCU
510f
MCU
510g
MCU
510h
BASE STATION
610c
MAIN STATION
710
716
700

FIG. 10

IVDS RADIO CHANNELS

CHANNEL	FREQUENCY (GROUP A)	FREQUENCY (GROUP B)
1	218.025	218.525
2	218.050	218.550
3	218.075	218.575
4	218.100	218.600
5	218.125	218.625
6	218.150	218.650
7	218.175	218.675
8	218.200	218.700
9	218.225	218.725
10	218.250	218.750
11	218.275	218.775
12	218.300	218.800
13	218.325	218.825
14	218.350	218.850
15	218.375	218.875
16	218.400	218.900
17	218.425	218.925
18	218.450	218.950
19	218.475	218.975

FIG. 11

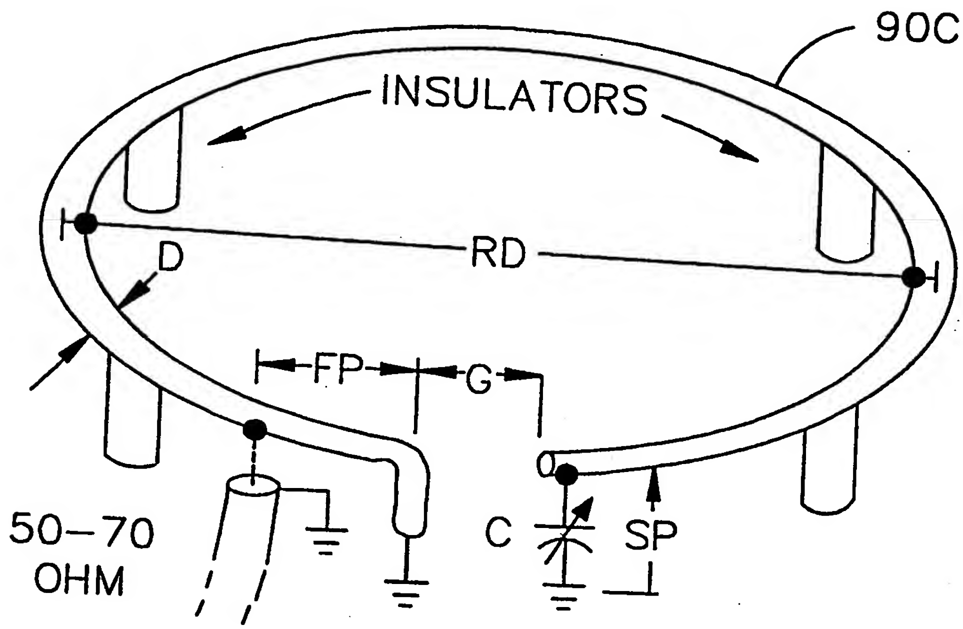


FIG. 12

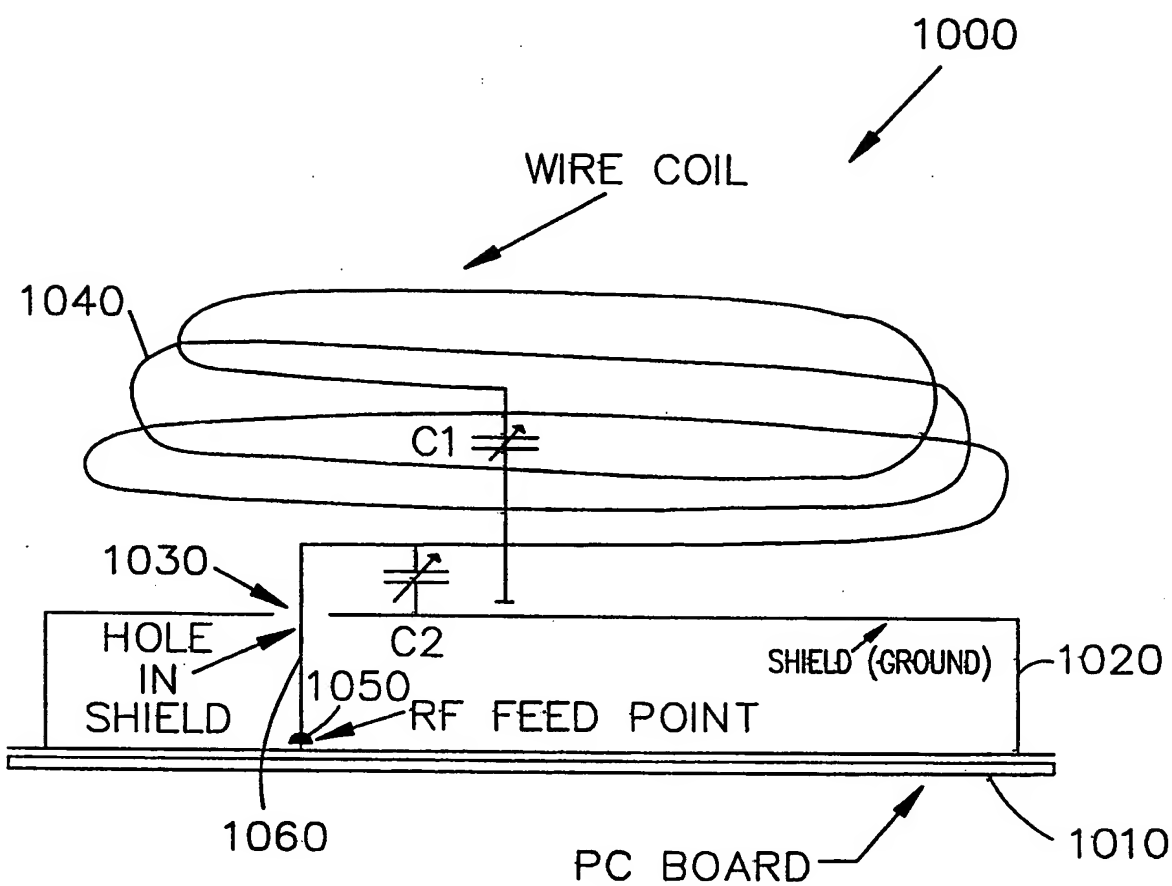

1000
WIRE COIL
1040
C1
1030
C2
HOLE IN SHIELD
SHIELD (GROUND)
1020
1050
RF FEED POINT
1060
PC BOARD
1010

FIG. 13

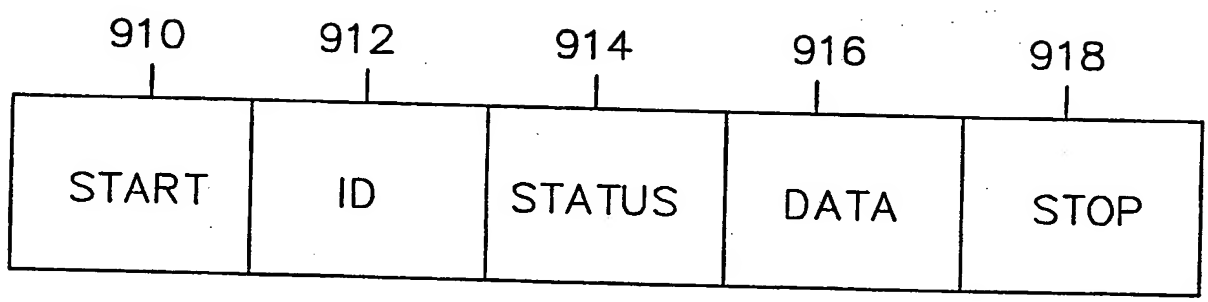


FIG. 14A

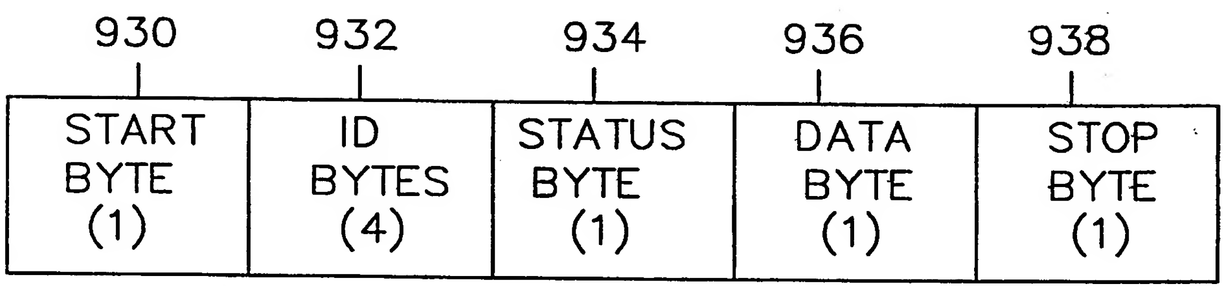

930
932
934
936
938
START BYTE (1)
ID BYTES (4)
STATUS BYTE (1)
DATA BYTE (1)
STOP BYTE (1)

FIG. 14B

STATUS BYTE TABLE

BIT LOCATION	DESCRIPTION
MSB 7	ERROR
6	UNUSED
5	UNUSED
4	UNUSED
3	UNUSED
2	UNUSED
1	DAYLIGHT PRESENT
LSB 0	AC ON TO LAMP

FIG. 15

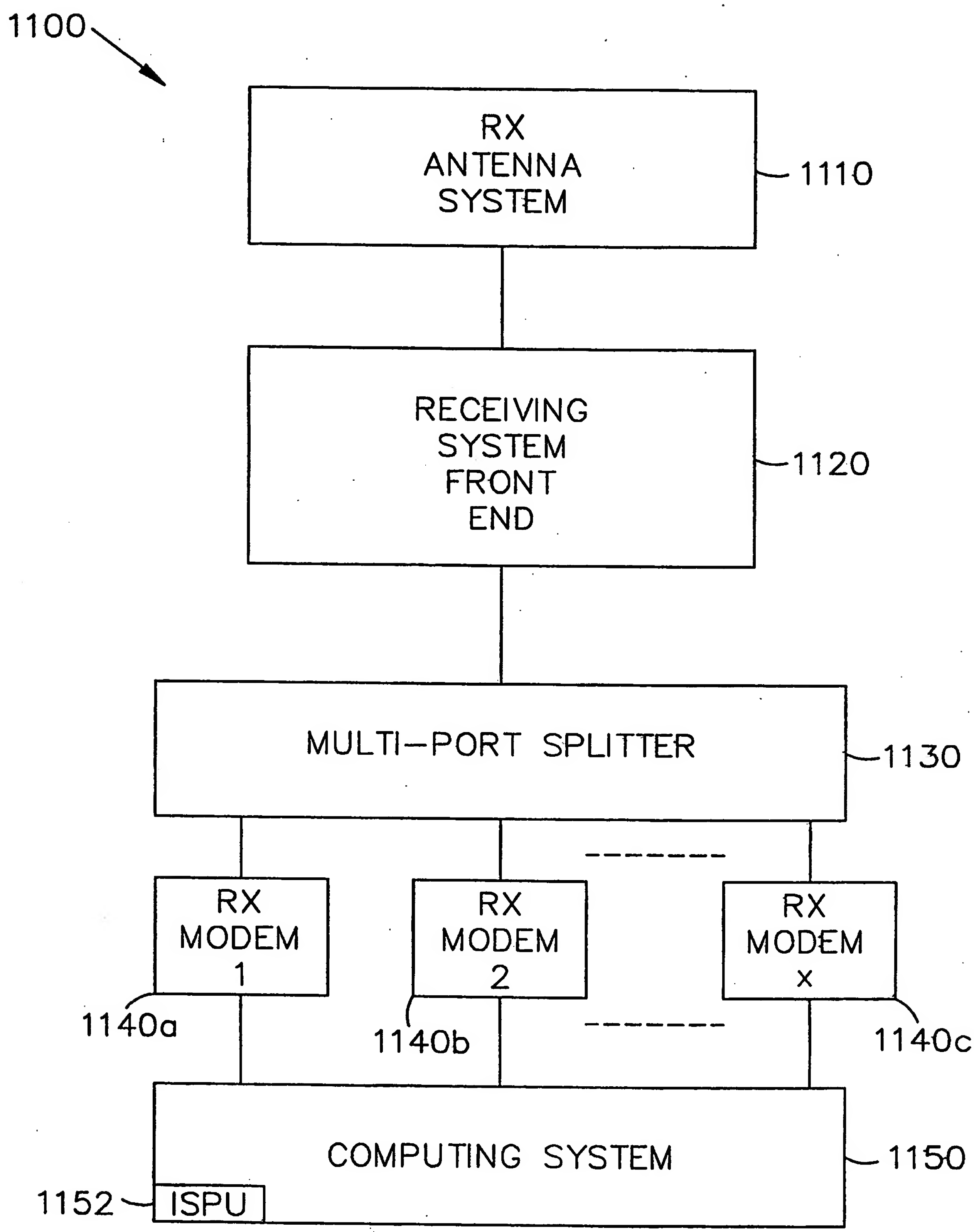

1100
RX
ANTENNA
SYSTEM
1110
RECEIVING
SYSTEM
FRONT
END
1120
MULTI-PORT SPLITTER
1130
RX
MODEM
1
RX
MODEM
2
RX
MODEM
x
1140a
1140b
1140c
COMPUTING SYSTEM
1150
1152
ISPU

FIG. 16A

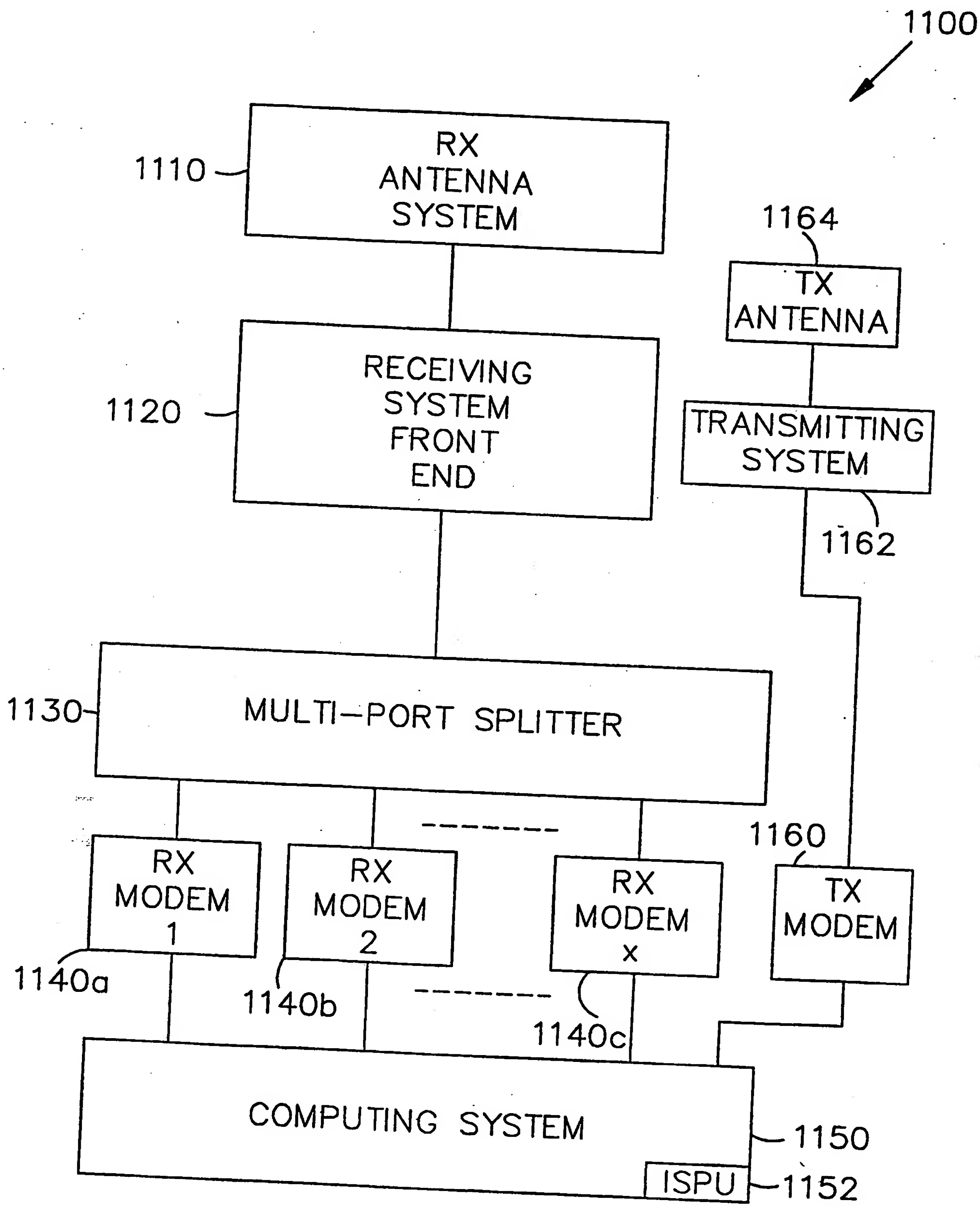

1100
RX ANTENNA SYSTEM
1110
RECEIVING SYSTEM FRONT END
1120
MULTI–PORT SPLITTER
1130
RX MODEM 1
RX MODEM 2
RX MODEM x
1140a
1140b
1140c
TX ANTENNA
1164
TRANSMITTING SYSTEM
1162
TX MODEM
1160
COMPUTING SYSTEM
ISPU
1150
1152

FIG. 16B

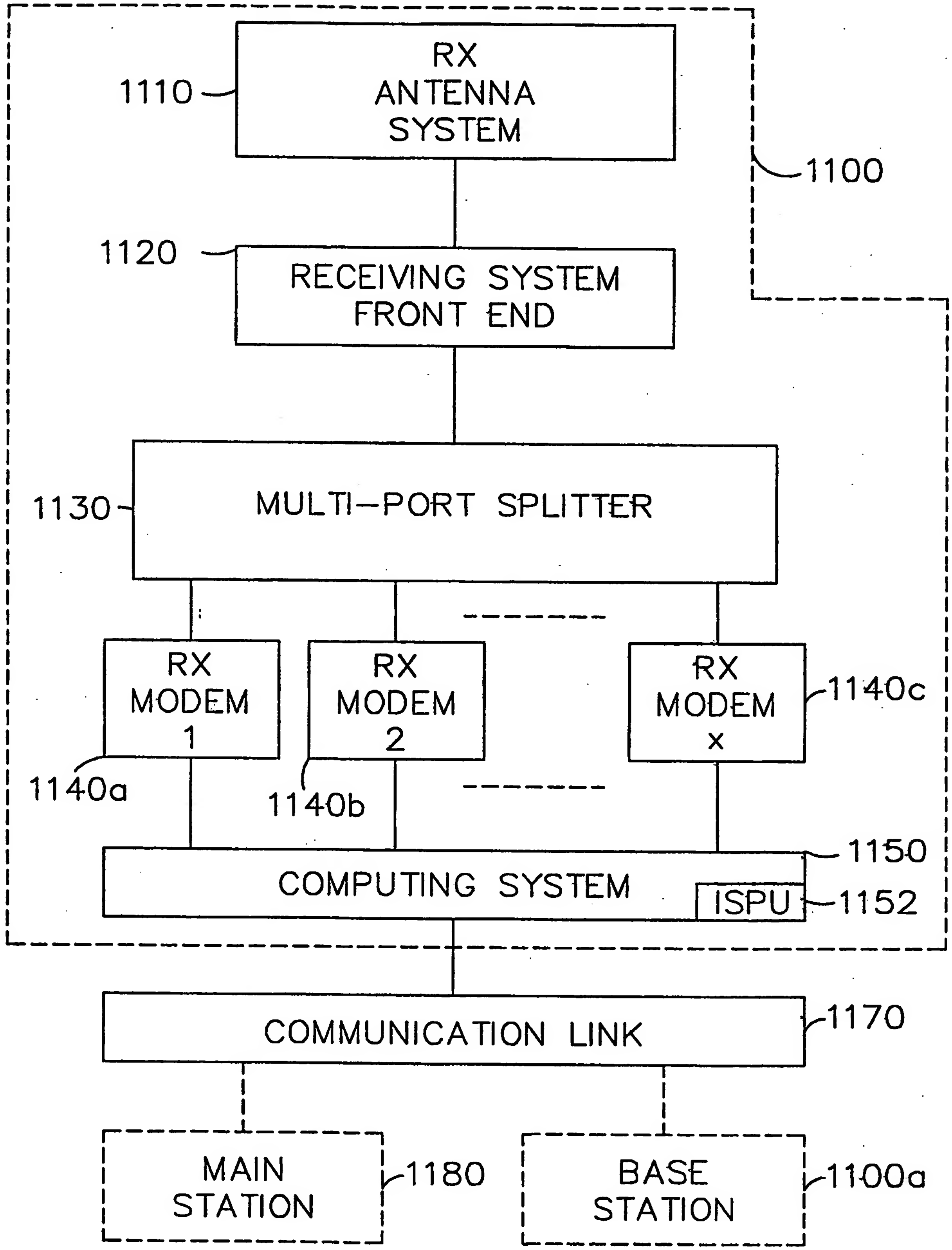

RX
ANTENNA
SYSTEM
1110
1100
1120
RECEIVING SYSTEM
FRONT END
1130
MULTI-PORT SPLITTER
RX
MODEM
1
RX
MODEM
2
RX
MODEM
x
1140c
1140a
1140b
1150
COMPUTING SYSTEM
ISPU
1152
COMMUNICATION LINK
1170
MAIN
STATION
1180
BASE
STATION
1100a

FIG. 16C

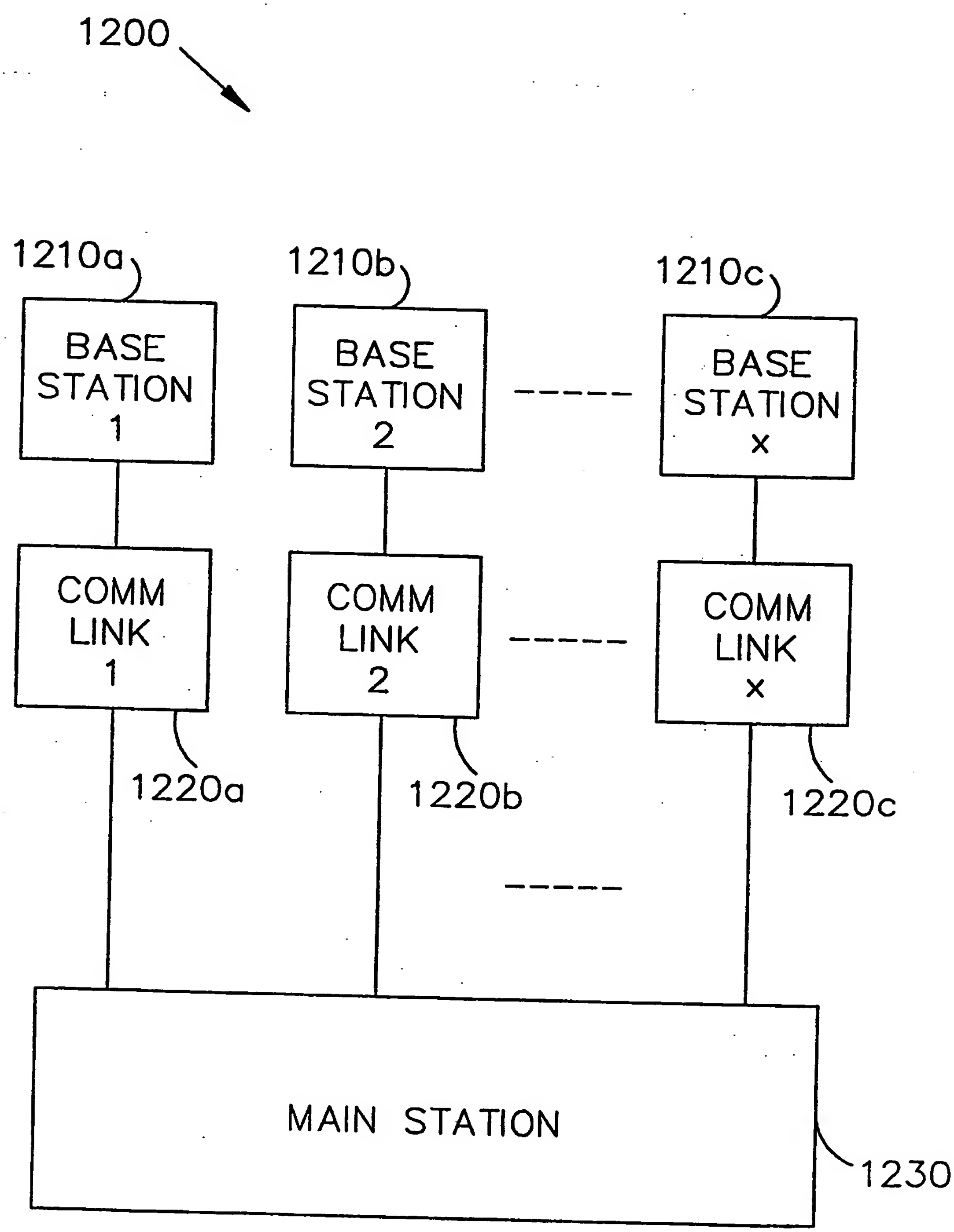

1200
1210a
1210b
1210c
BASE STATION 1
BASE STATION 2
BASE STATION x
COMM LINK 1
COMM LINK 2
COMM LINK x
1220a
1220b
1220c
MAIN STATION
1230

FIG. 17

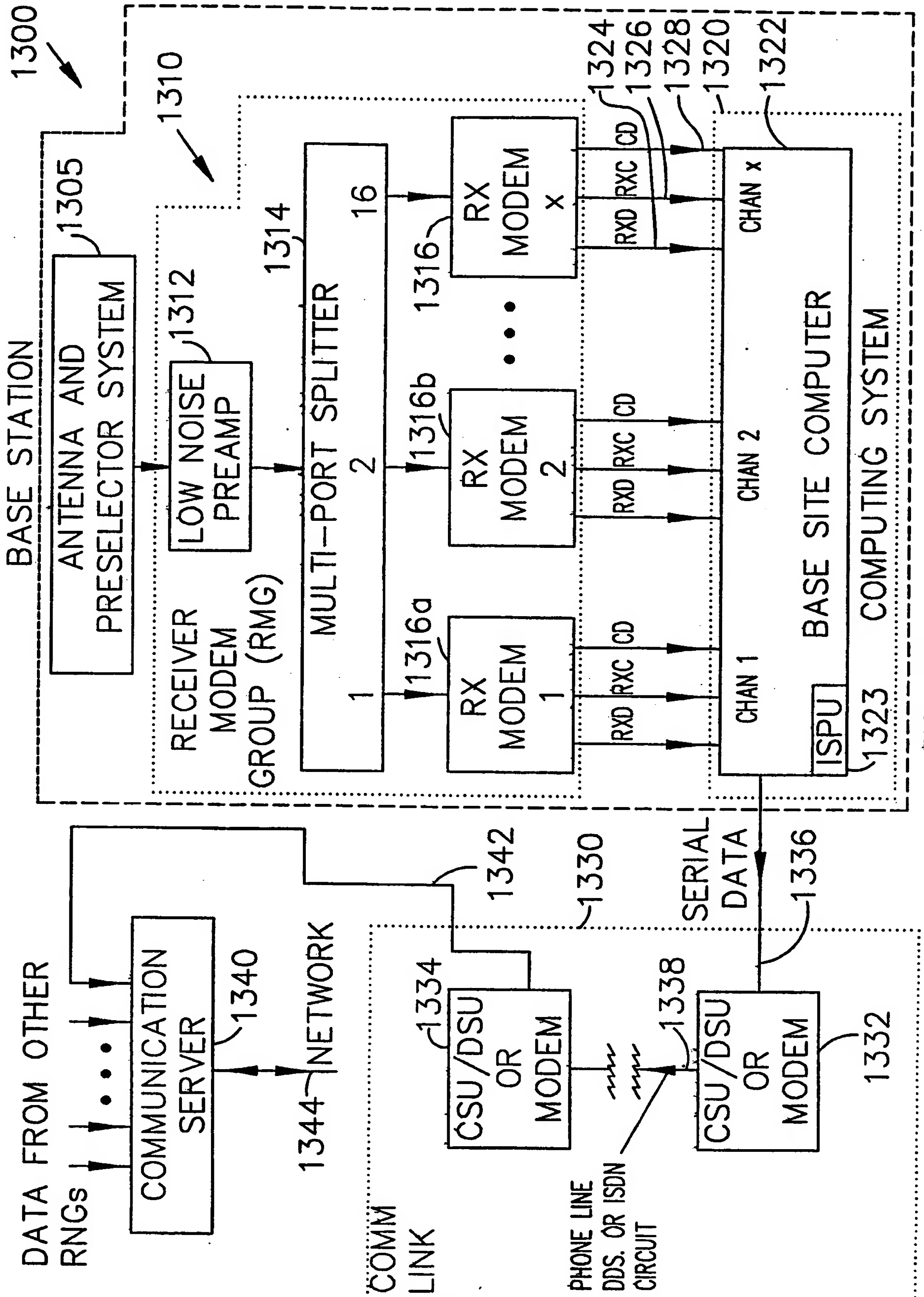

1300
BASE STATION
ANTENNA AND PRESELECTOR SYSTEM
1305
1310
RECEIVER MODEM GROUP (RMG)
LOW NOISE PREAMP
1312
MULTI-PORT SPLITTER
1314
1
2
16
RX MODEM 1
RX MODEM 2
RX MODEM x
1316a
1316b
1316
RXD RXC CD
1324
1326
1328
1320
1322
CHAN 1
CHAN 2
CHAN x
BASE SITE COMPUTER
COMPUTING SYSTEM
ISPU
1323
SERIAL DATA
1336
1330
1342
DATA FROM OTHER RNGs
COMMUNICATION SERVER
1340
NETWORK
1344
COMM LINK
CSU/DSU OR MODEM
1334
1338
1332
PHONE LINE DDS. OR ISDN CIRCUIT

FIG. 18

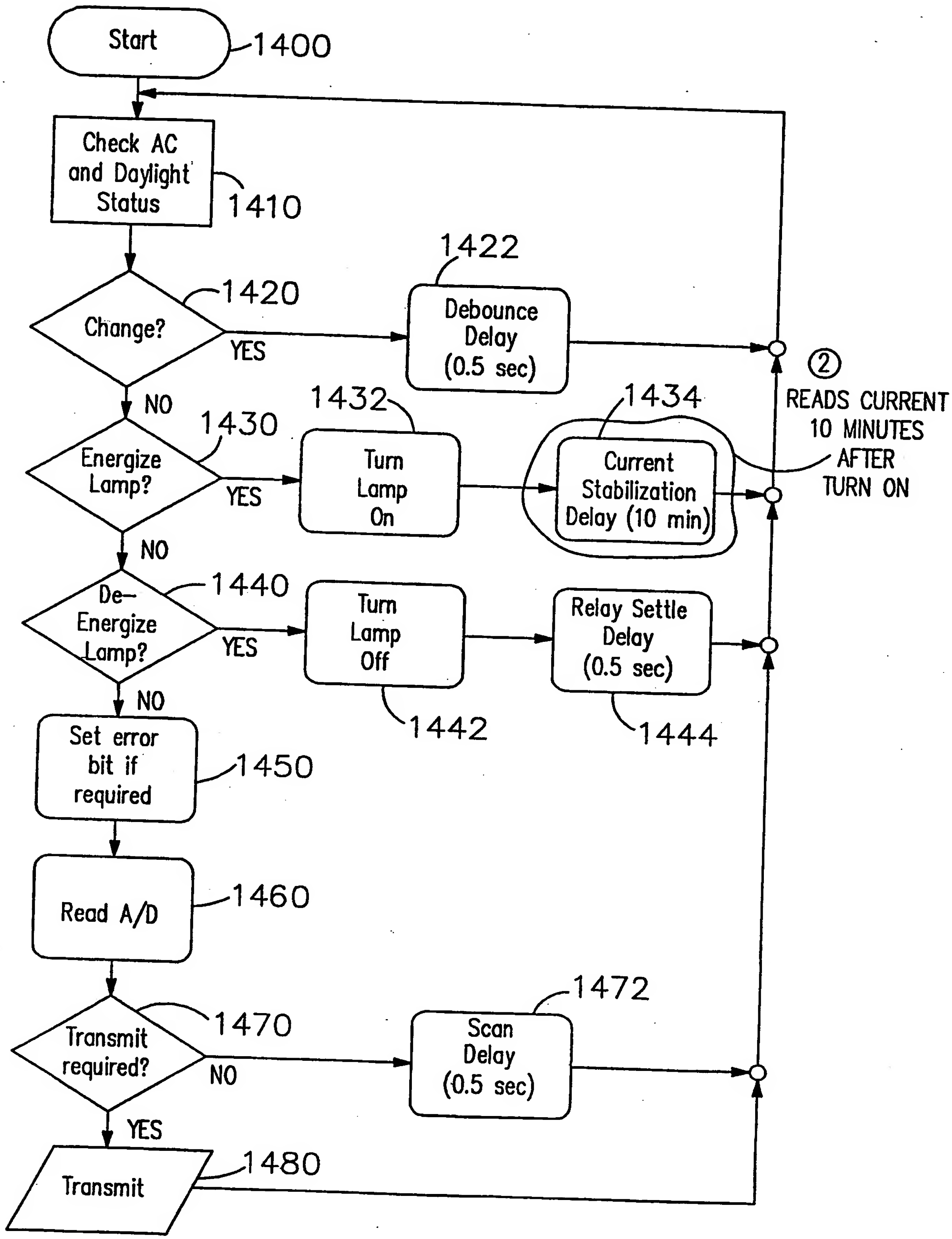

Start
1400
Check AC and Daylight Status
1410
Change?
1420
YES
NO
Debounce Delay (0.5 sec)
1422
Energize Lamp?
1430
YES
NO
Turn Lamp On
1432
Current Stabilization Delay (10 min)
1434
2
READS CURRENT 10 MINUTES AFTER TURN ON
De-Energize Lamp?
1440
YES
NO
Turn Lamp Off
1442
Relay Settle Delay (0.5 sec)
1444
Set error bit if required
1450
Read A/D
1460
Transmit required?
1470
NO
YES
Scan Delay (0.5 sec)
1472
Transmit
1480

FIG. 19A

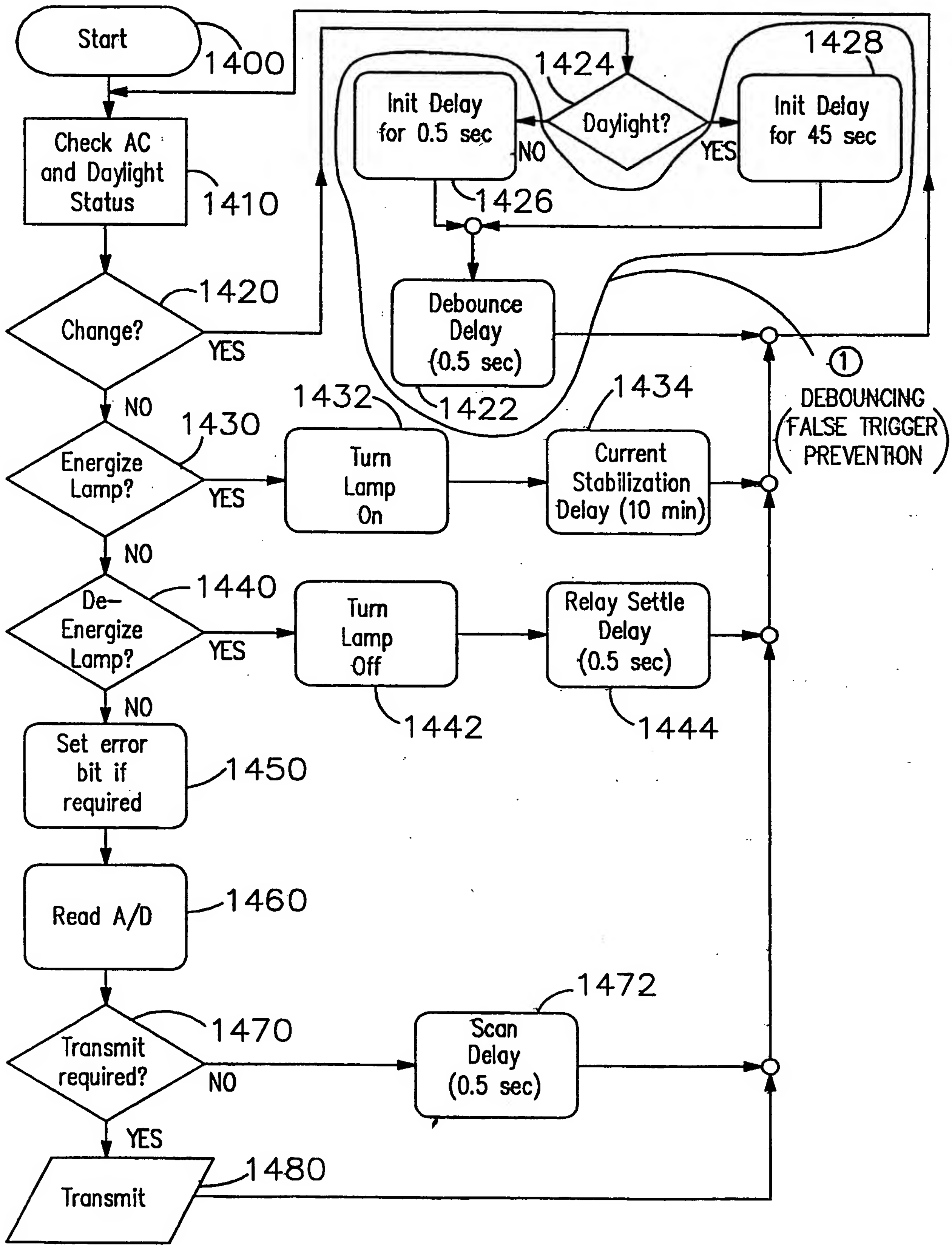

Start
1400
Check AC and Daylight Status
1410
Change?
1420
YES
NO
Energize Lamp?
1430
YES
NO
De-Energize Lamp?
1440
YES
NO
Set error bit if required
1450
Read A/D
1460
Transmit required?
1470
NO
YES
Transmit
1480
Daylight?
1424
Init Delay for 0.5 sec
NO
Init Delay for 45 sec
YES
1428
1426
Debounce Delay (0.5 sec)
1422
1
DEBOUNCING FALSE TRIGGER PREVENTION
Turn Lamp On
1432
Current Stabilization Delay (10 min)
1434
Turn Lamp Off
1442
Relay Settle Delay (0.5 sec)
1444
Scan Delay (0.5 sec)
1472

FIG. 19B

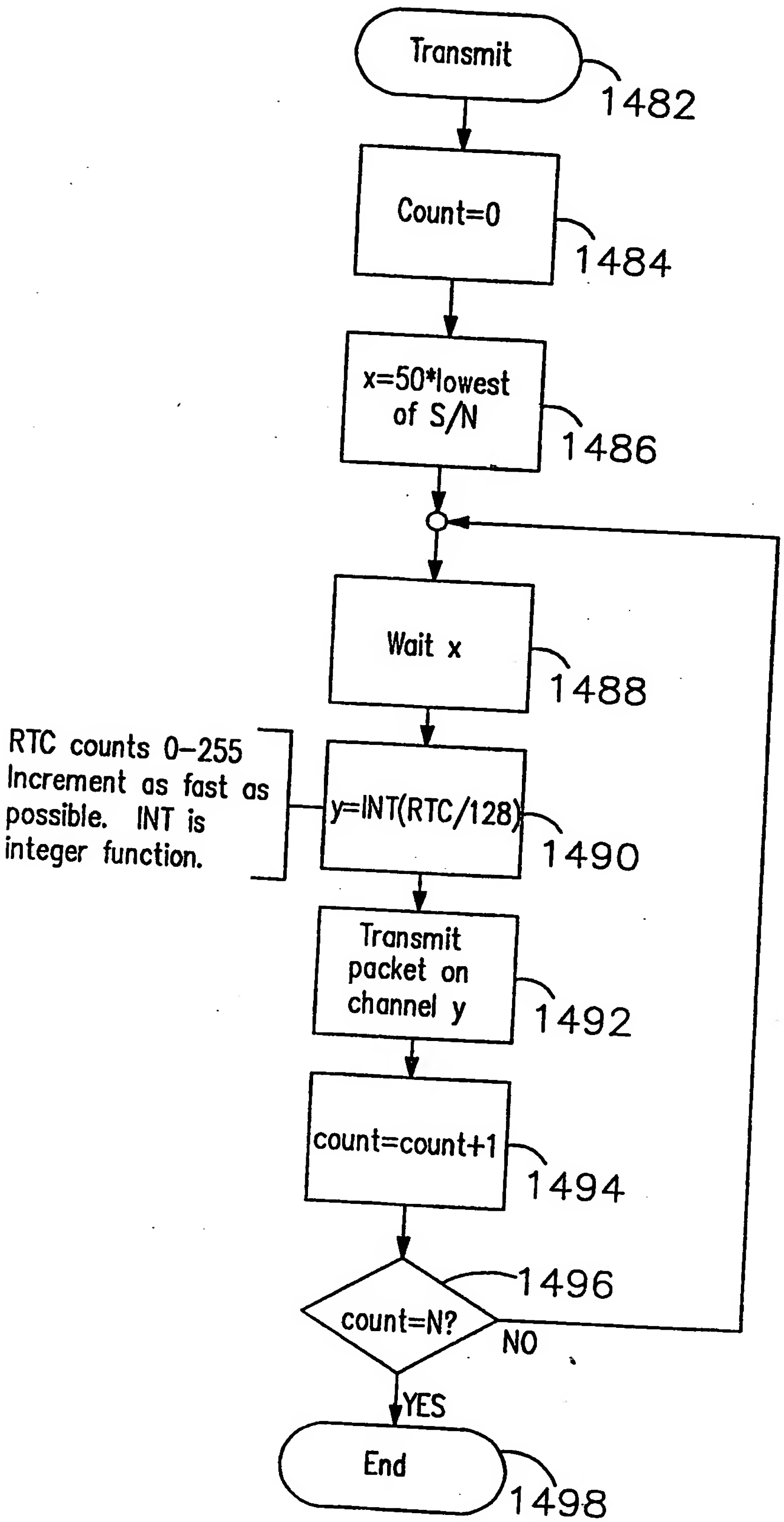

Transmit
1482
Count=0
1484
x=50*lowest of S/N
1486
Wait x
1488
RTC counts 0-255 Increment as fast as possible. INT is integer function.
y=INT(RTC/128)
1490
Transmit packet on channel y
1492
count=count+1
1494
1496
count=N?
NO
YES
End
1498

FIG. 19C

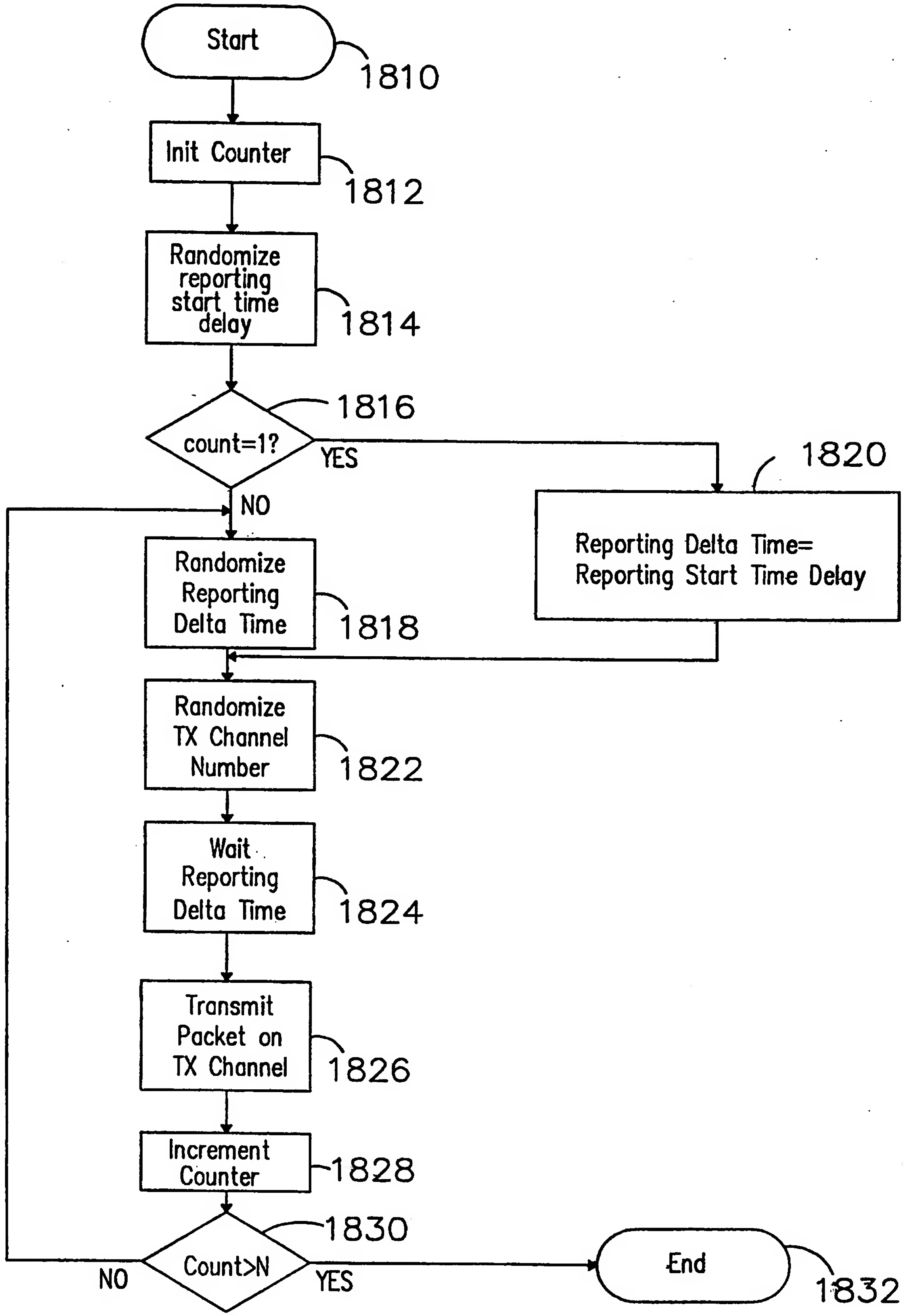

Start
1810
Init Counter
1812
Randomize reporting start time delay
1814
count=1?
1816
YES
NO
1820
Reporting Delta Time= Reporting Start Time Delay
Randomize Reporting Delta Time
1818
Randomize TX Channel Number
1822
Wait Reporting Delta Time
1824
Transmit Packet on TX Channel
1826
Increment Counter
1828
Count>N
1830
NO
YES
End
1832

FIG. 19D

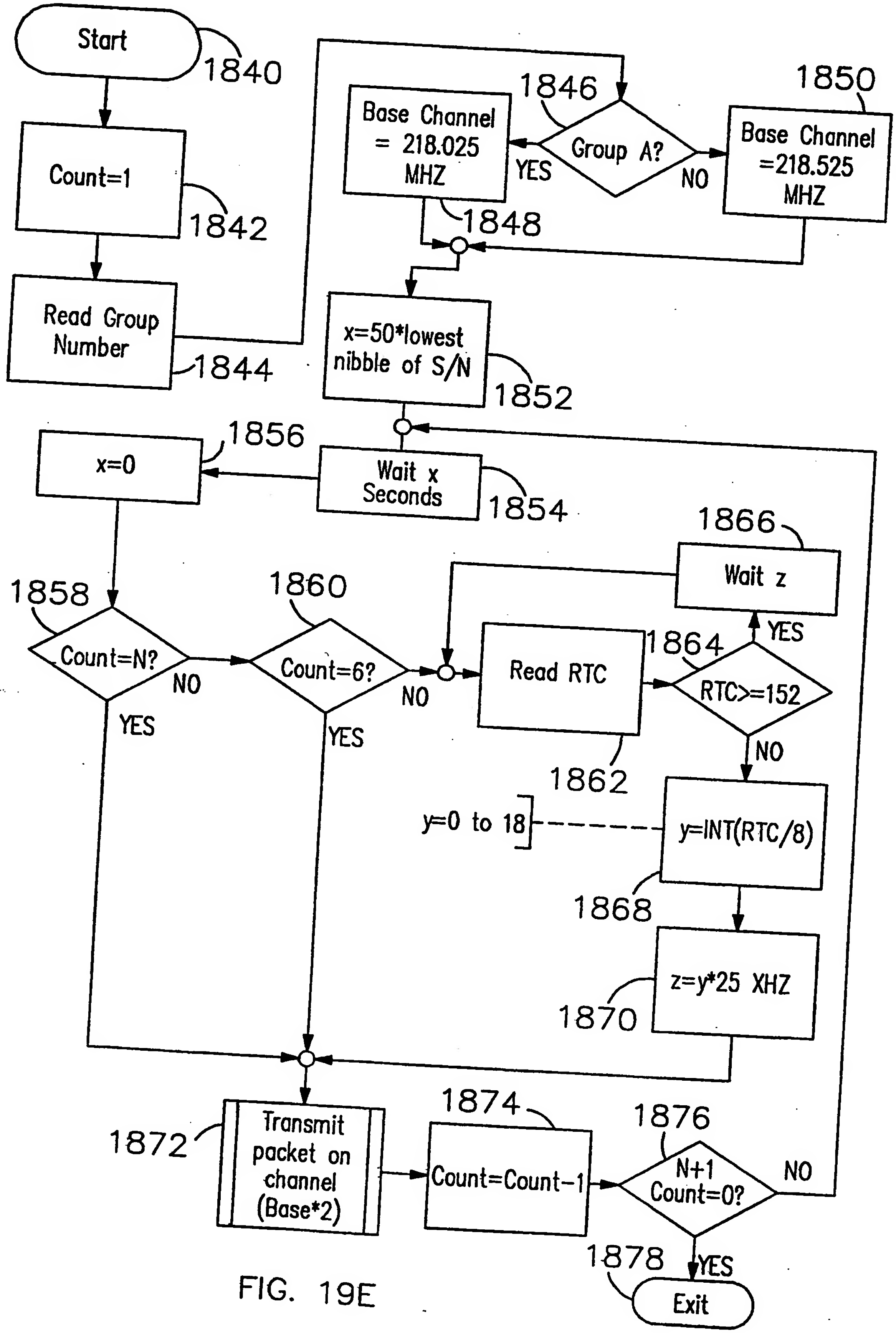

Start
1840
Count=1
1842
Read Group Number
1844
1846
Group A?
YES
NO
Base Channel = 218.025 MHZ
1848
1850
Base Channel =218.525 MHZ
x=50*lowest nibble of S/N
1852
Wait x Seconds
1854
x=0
1856
1858
Count=N?
NO
YES
1860
Count=6?
NO
YES
Read RTC
1862
1864
RTC>=152
YES
NO
1866
Wait z
y=0 to 18
y=INT(RTC/8)
1868
z=y*25 XHZ
1870
1872
Transmit packet on channel (Base*2)
1874
Count=Count-1
1876
N+1 Count=0?
NO
YES
1878
Exit

FIG. 19E

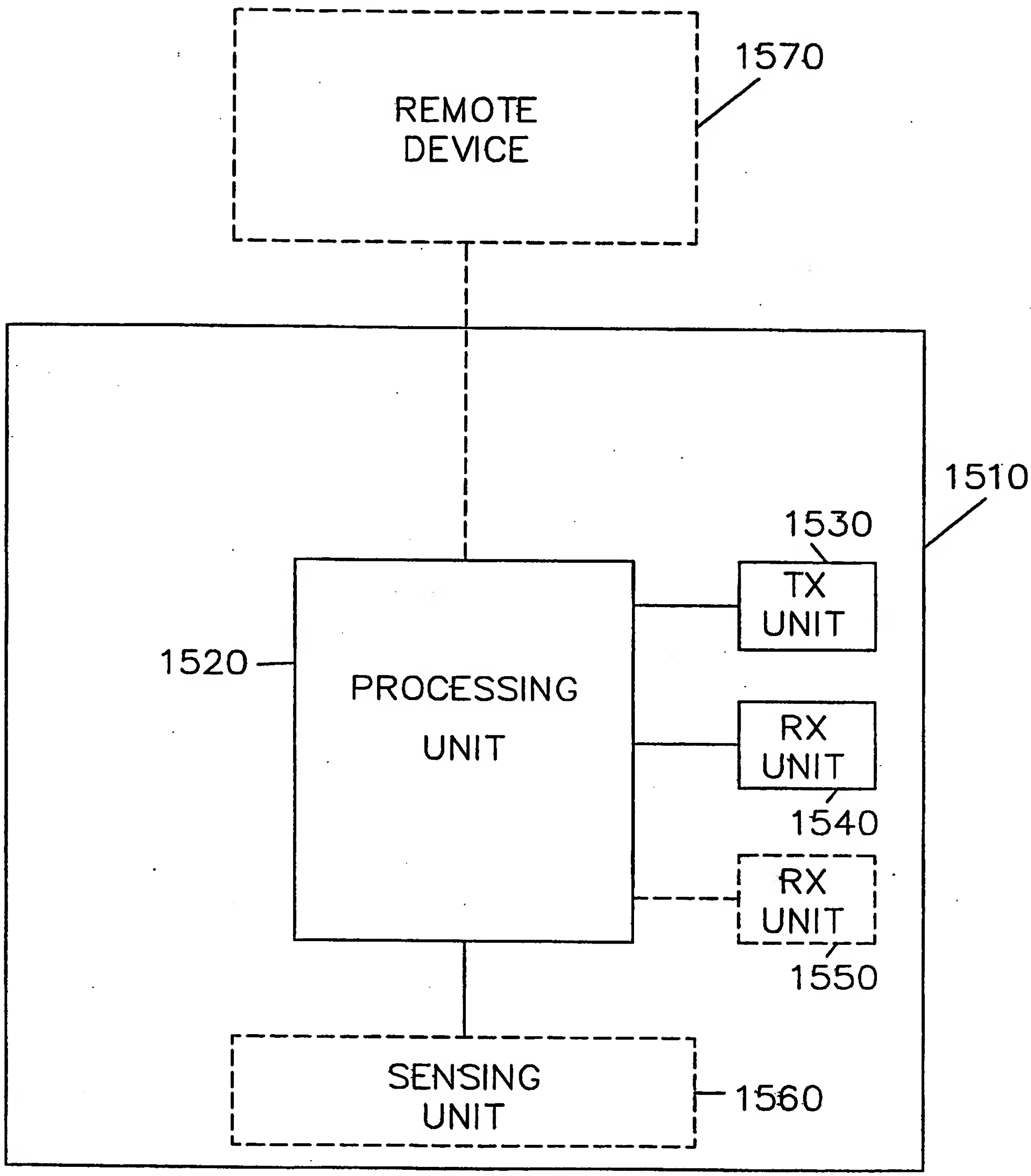

REMOTE
DEVICE
1570
1510
1530
TX
UNIT
1520
PROCESSING
UNIT
RX
UNIT
1540
RX
UNIT
1550
SENSING
UNIT
1560

FIG. 20

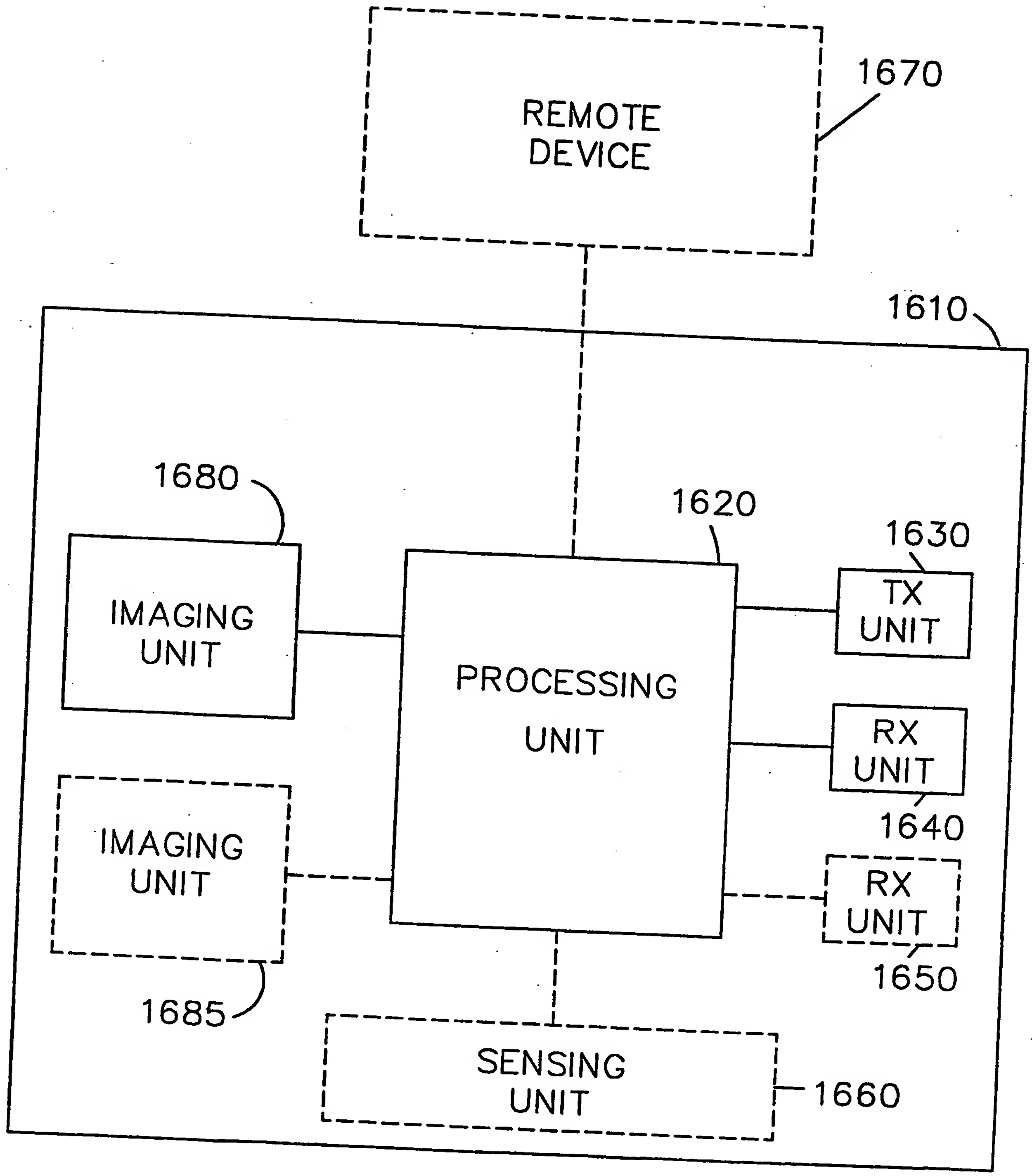

REMOTE DEVICE
1670
1610
1680
IMAGING UNIT
1620
PROCESSING UNIT
1630
TX UNIT
RX UNIT
1640
IMAGING UNIT
RX UNIT
1650
1685
SENSING UNIT
1660

FIG. 21

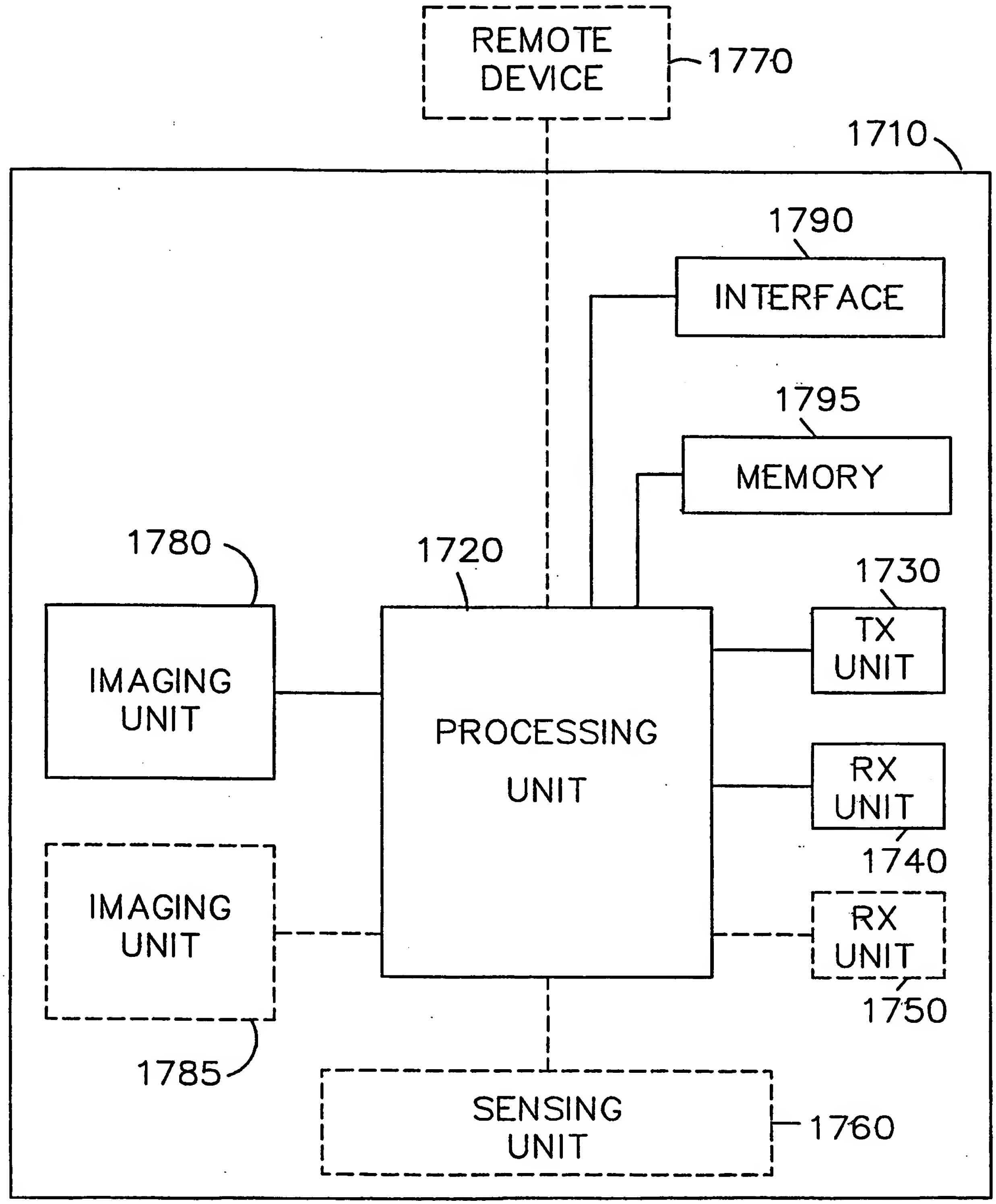

REMOTE DEVICE
1770
1710
1790
INTERFACE
1795
MEMORY
1780
1720
1730
TX UNIT
IMAGING UNIT
PROCESSING UNIT
RX UNIT
1740
IMAGING UNIT
RX UNIT
1750
1785
SENSING UNIT
1760

FIG. 22

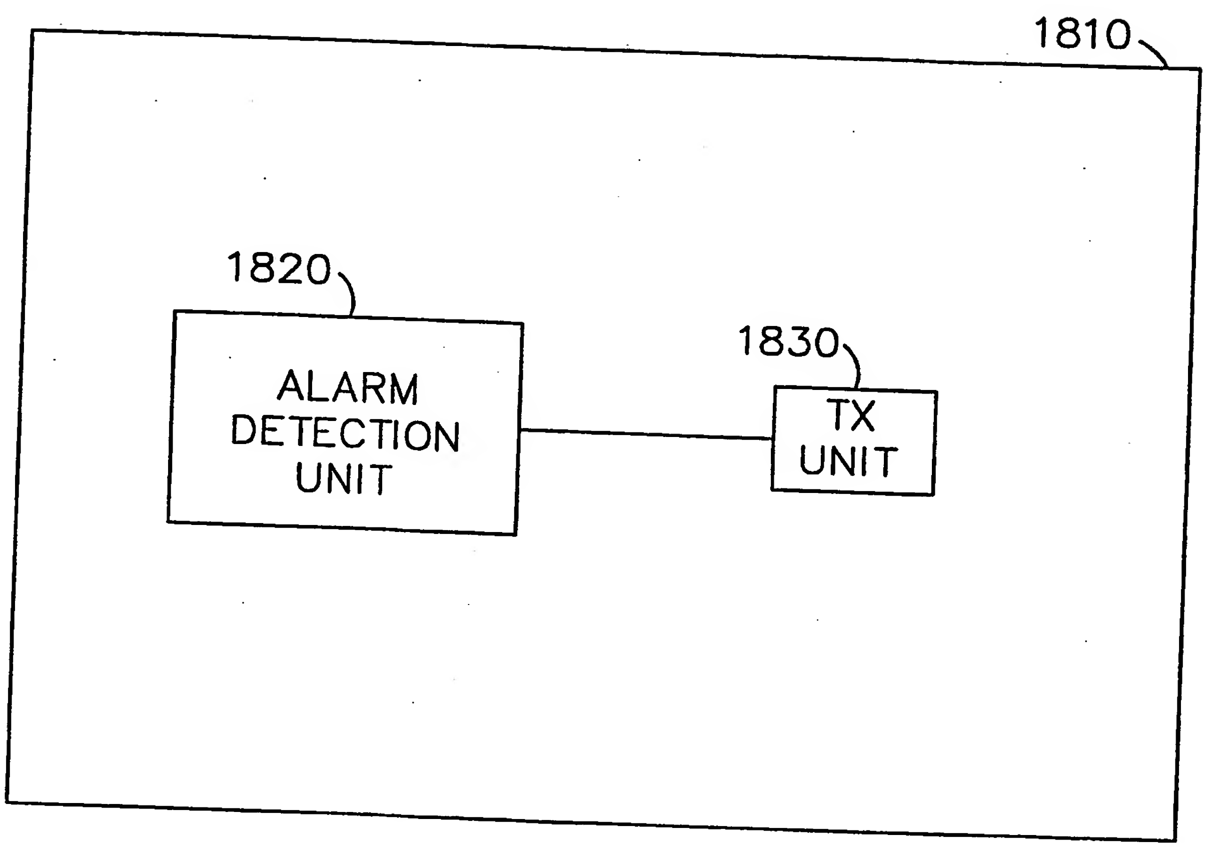


FIG. 23

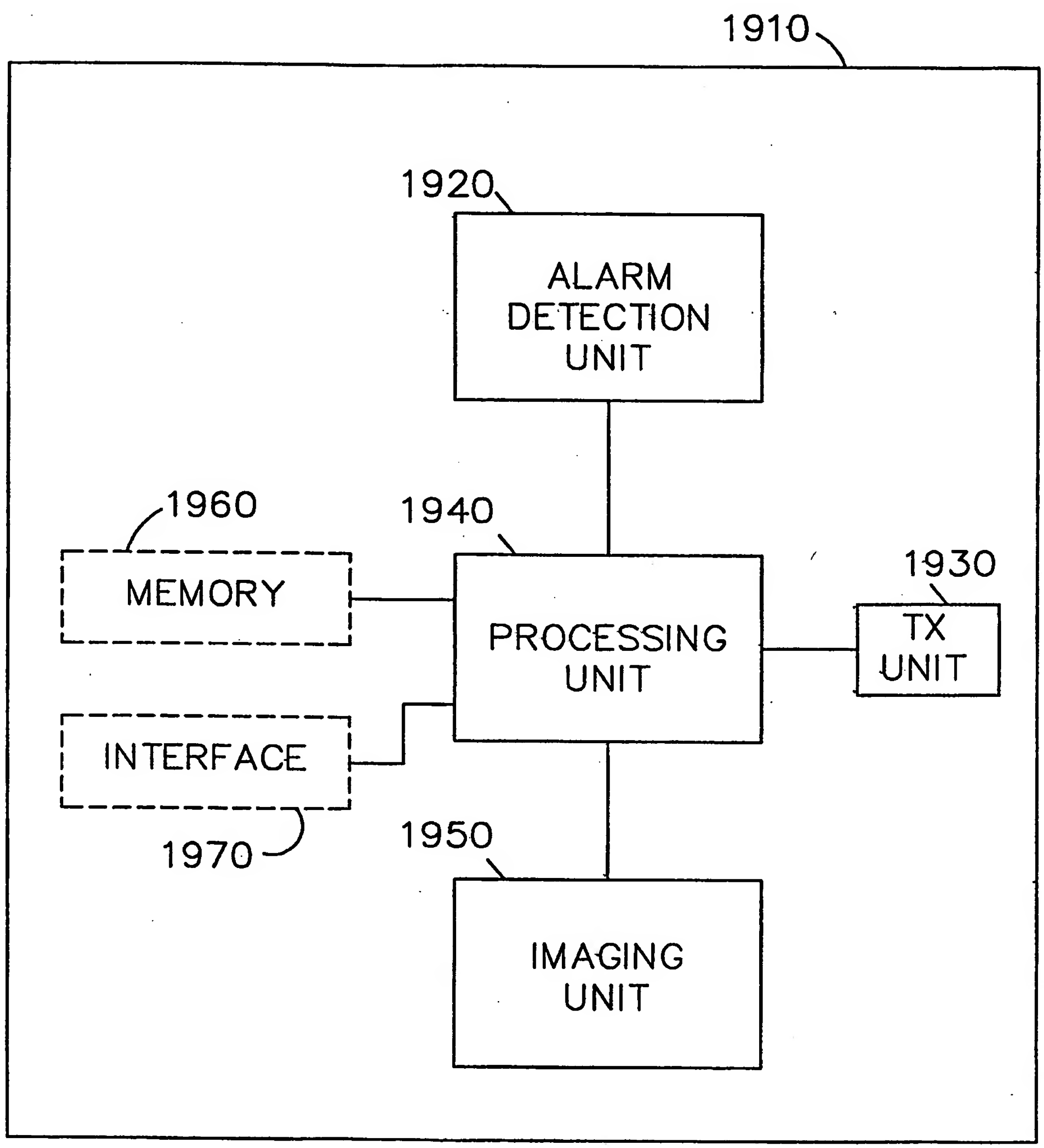

1910
1920
ALARM DETECTION UNIT
1960
MEMORY
1940
PROCESSING UNIT
1930
TX UNIT
INTERFACE
1970
1950
IMAGING UNIT

FIG. 24

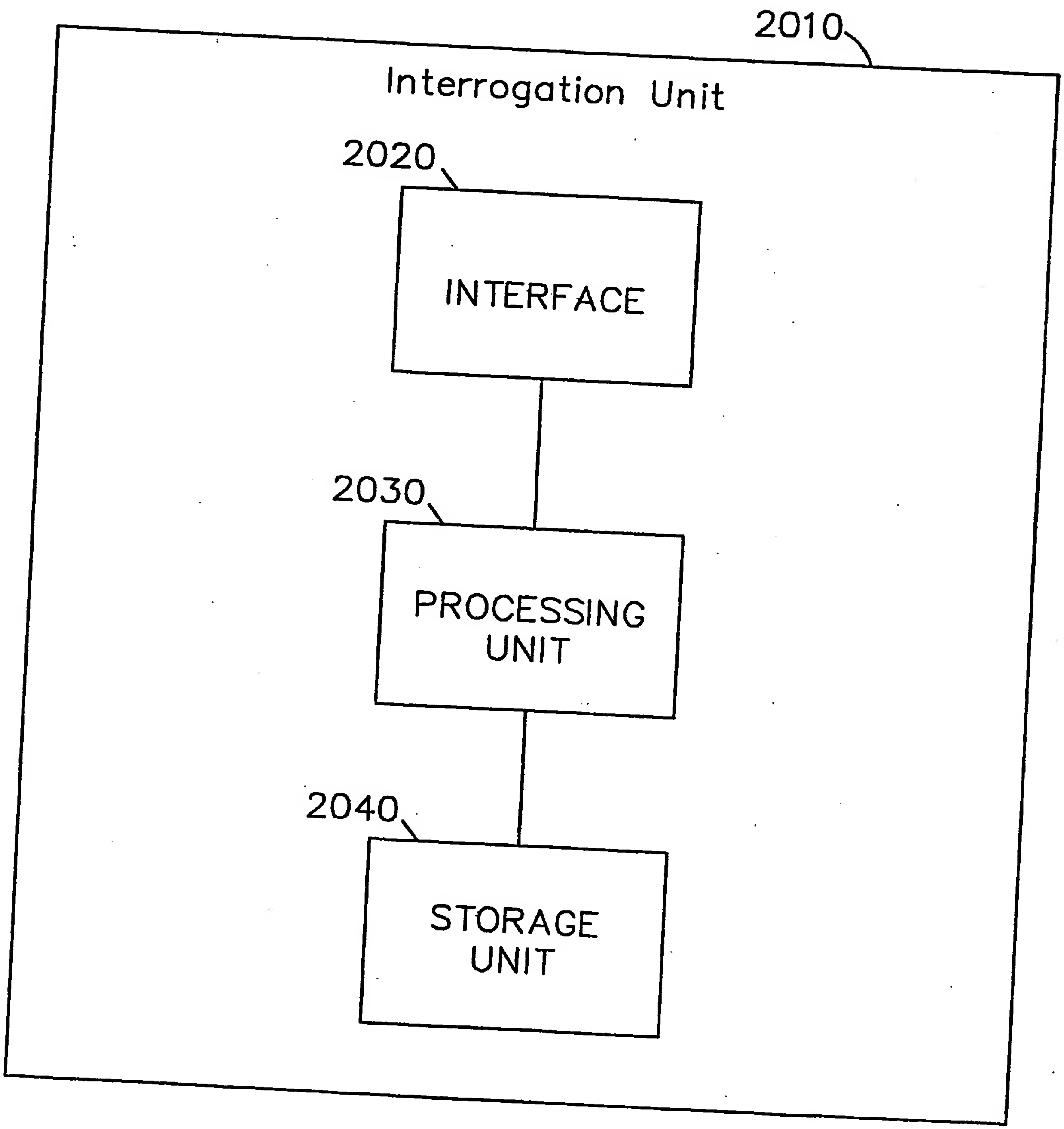

2010
Interrogation Unit
2020
INTERFACE
2030
PROCESSING UNIT
2040
STORAGE UNIT

FIG. 25

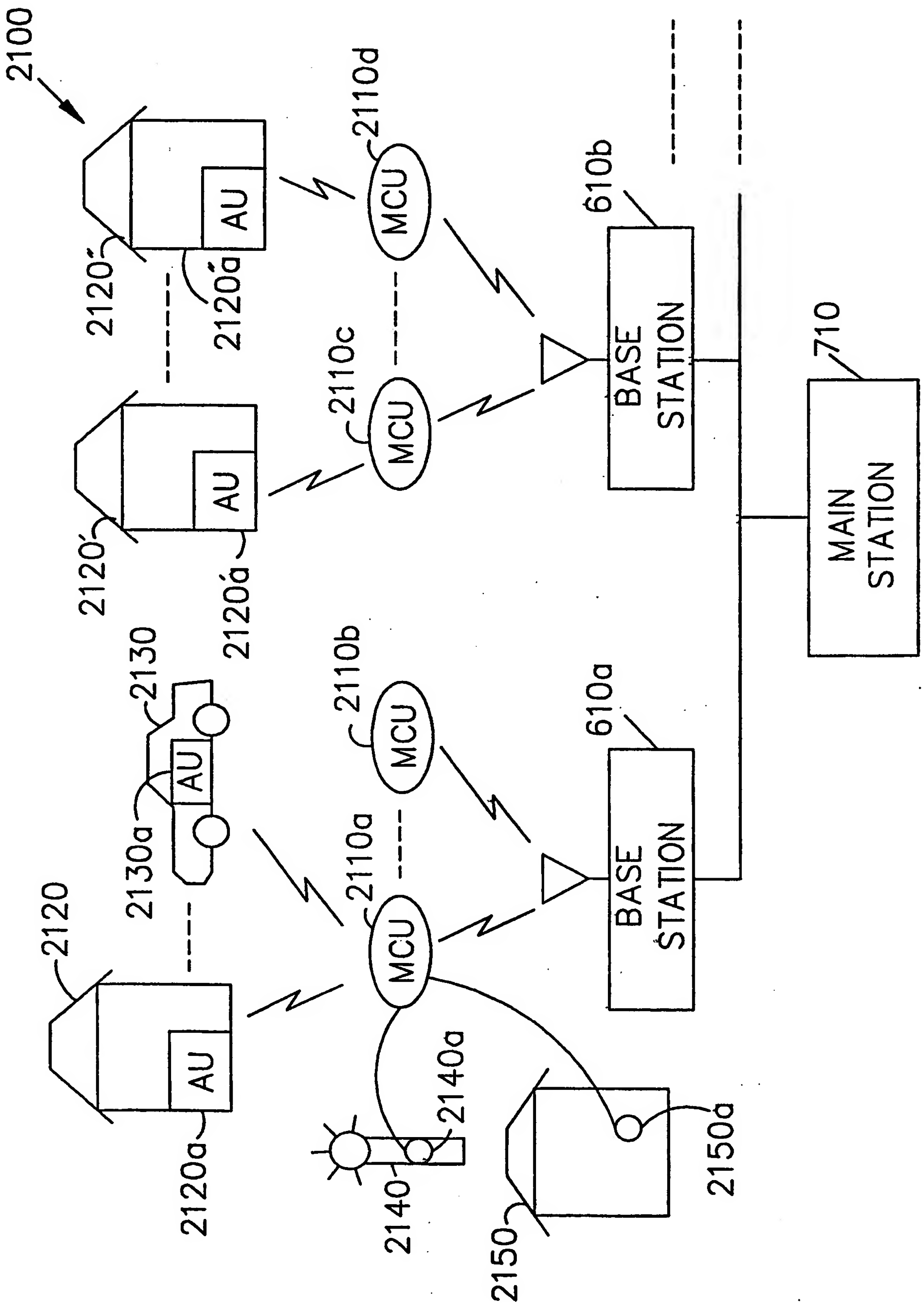

2100
AU
MCU
BASE STATION
MAIN STATION
2120
2120a
2120'
2120a'
2120"
2120a"
2130
2130a
2110a
2110b
2110c
2110d
2140
2140a
2150
2150a
610a
610b
710

FIG. 26

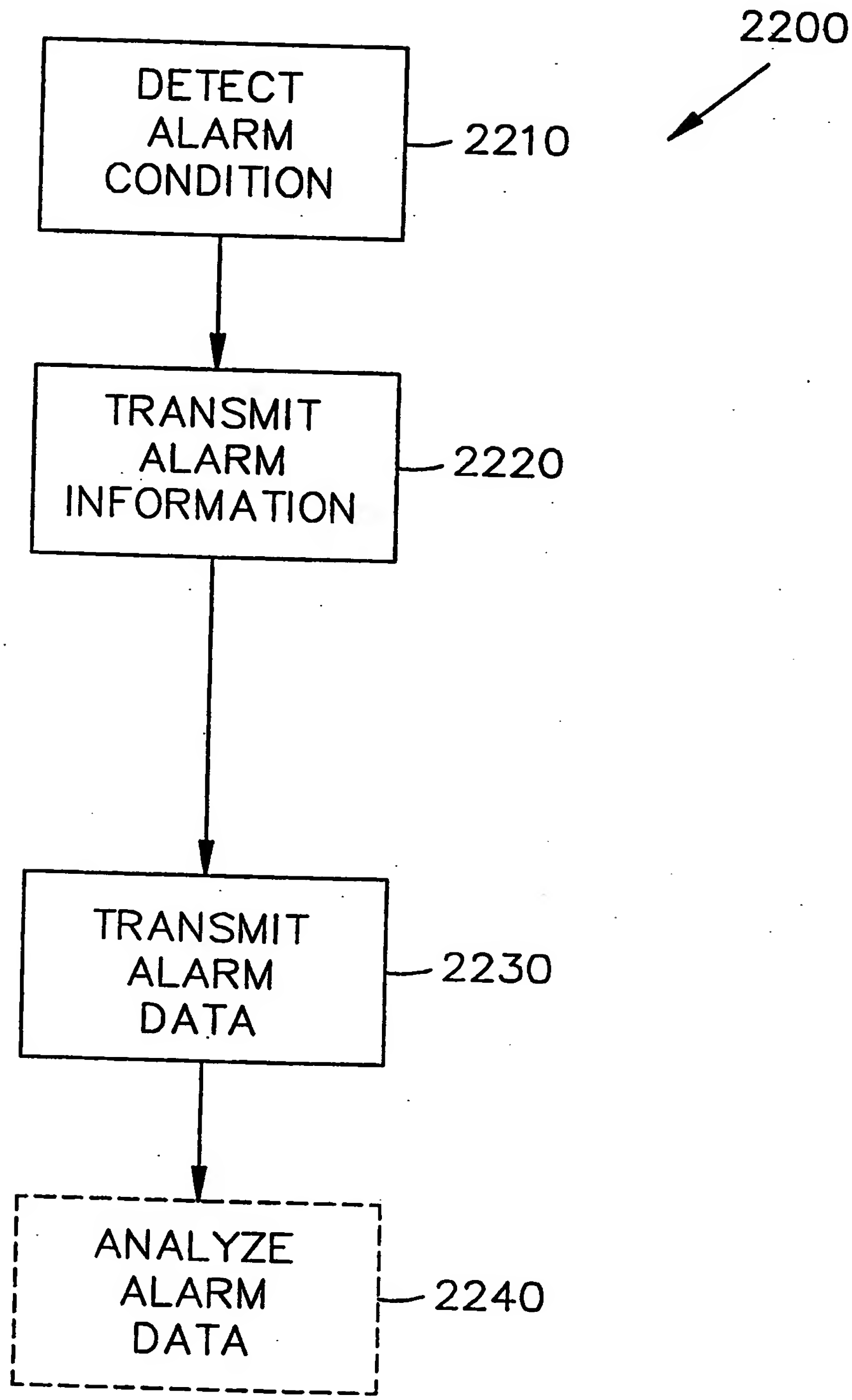

2200
DETECT ALARM CONDITION
2210
TRANSMIT ALARM INFORMATION
2220
TRANSMIT ALARM DATA
2230
ANALYZE ALARM DATA
2240

FIG. 27

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/07498

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :G08C 19/04
US CL : 702/188
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

USPTO APS, USPTO MAYA, STIC/EIC DIALOG

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,E	US, 5,748,104 A (ARGYROUDIS ET AL) 05 May 1998 (05/05/98), Figs. 1-2 and cols. 4 -15.	18-25, 28-29, 37-41, 48-50
A	US 5,598,456 A (FEINBERG) 28 January 1997 (28/01/97), whole document.	1-56
A	US 4,406,995 A (MAY) 27 September 1983 (27/09/83), whole document.	1-56
A	US 5,586,050 A (MAKEL ET AL) 17 December 1996 (17/12/96), whole document.	1-56
A	US 4,580,099 A (ZETTI) 01 April 1986 (01/04/86), whole document.	1-56

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 JUNE 1998	05 AUG 1998

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	PATRICK J. ASSOUAD
Facsimile No. (703) 305-3230	Telephone No. (703) 305-3811

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/07498

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

702/188,57; 315/129, 133, 134, 149; 364/130, 138; 340/870.01, 870.07, 870.16, 825.06
455/422, 403, 423, 73

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claim(s) 1-8, 9-17, and 55 and 56, drawn to a "lamp monitoring and control unit" or a "method for monitoring and controlling a lamp" or a "monitoring and control system...to control operations of a street lamp", which comprises either "a control unit..." and a "transmit unit..when a condition of the lamp changes" or "detecting an amount of ambient light...sensing at least one lamp parameter...transmitting the sensed parameter data to a central location when a state of the lamp changes", or a "plurality of alarm units for detecting an alarm condition...and at least one monitoring and control unit...coupled to an associated street lamp to control operations of the street lamp based on ambient light conditions", respectively.

Group II, claim(s) 18-32, 37-40, 41-49, and 50-54, drawn to a "system for monitoring and controlling a plurality of remote device" or a "method of monitoring and reporting the status of a remote device", or an "alarm monitoring and control system" or to a "method for alarm monitoring", which comprises either a "plurality of control units...each...transmit monitoring data..and at least one base station...for processing the monitoring data" or "monitoring a state of a remote device, and transmitting status...to a central location...", or "at least one alarm unit...a transmit unit... and at least one relay unit...and a transmitter for transmitting the alarm information to a central location", or "detecting an alarm condition...transmitting alarm information...further transmitting alarm data...and analyzing the alarm data to determine a location of the alarm unit...", respectively.

Group III, claim(s) 33-36, drawn to a "base station for receiving monitoring data".